OLUME 48 NUMBER 1

TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY

An International Quarterly Journal

March, 1943

Founded by LOUIS A. BAUER
Conducted by J. A. FLEMING
With the Cooperation of Eminent Investigators

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PUBLISHED FOR
THE JOHNS HOPKINS PRESS, BALTIMORE, MARYLAND
THE RUTER PRESS, 420 PLUM ST., CINCINNATI, OHIO
THREE DOLLARS AND FIFTY CENTS A YEAR SINGLE NUMBERS, ONE DOLLAR

THE JOHNS HOPKINS PRESS
BALTIMORE, MARYLAND
Entered as second-class matter at the Post-office at Cincinnati, Ohio

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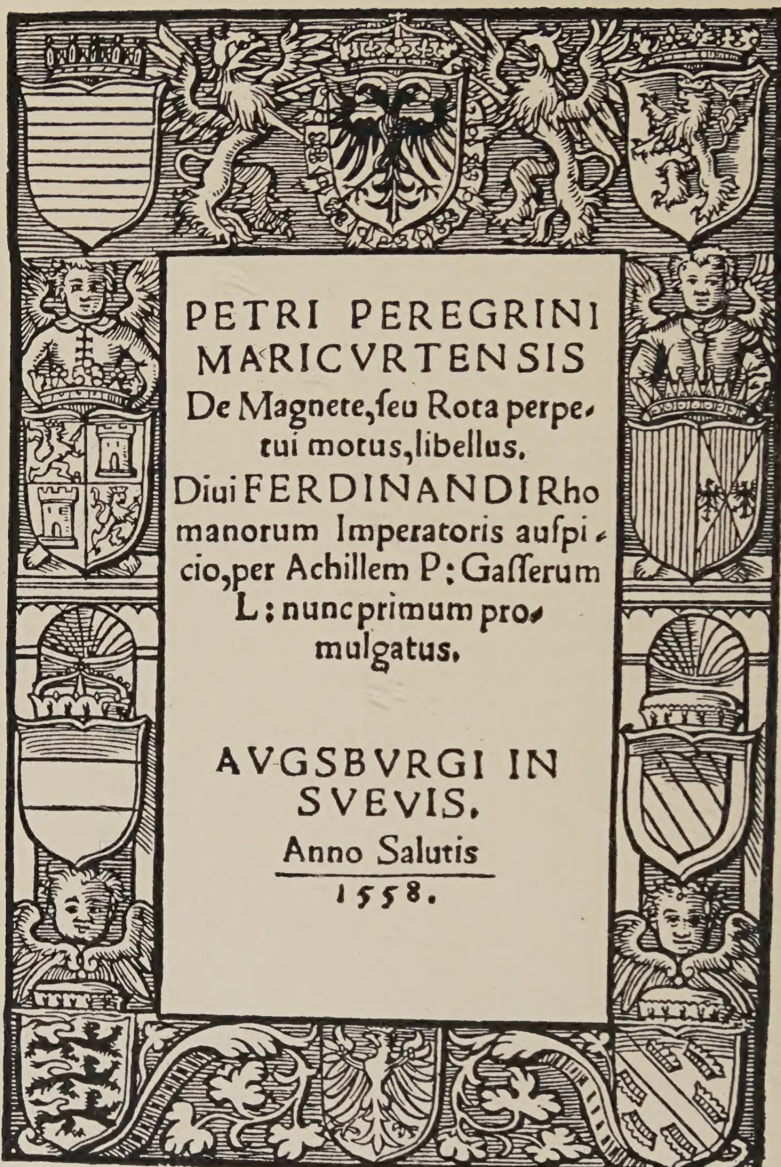


PETRI PEREGRINI
MARICVRTENSIS
De Magnete, seu Rota perpe-
tui motus, libellus.
Diui FERDINANDI Rho
manorum Imperatoris auspi-
cio, per Achillem P: Gasserum
L: nunc primum pro-
mulgatus.

AVGSBVRGI IN
SVEVIS.
Anno Salutis
1558.

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME 48 MARCH, 1943 No. 1

ARCHAEOLOGICA GEOMAGNETICA

BY SYDNEY CHAPMAN

Today the well-being of the average citizen is linked with social and economic events widespread over the world. The future of human life will depend more and more on the education, the intelligence, and the knowledge of the common man. Knowledge increases continually in range and complexity, and the days in which a man might master almost the whole of human learning lie far behind us. The citizen should have a rational though of course simple conception of the world as it is today, and of the past history of man and the world; how to achieve this is one of the great problems of education.

In a narrower sphere a like problem arises for the teacher of science, in view of its rapid growth in all directions. Experience suggests that for science students in universities the few years of undergraduate study are best devoted to the central and most fundamental parts of mathematics and science, which provide a foundation on which students can afterwards build a more specialized superstructure according to their individual tastes and professional needs. In teaching these central subjects, logic, order, and a vital interest are more helpful than history; but nevertheless it seems good to acquaint students briefly with the origins of their subject, in the thoughts and work of the great men of the past. A youth filled with zeal for knowledge and research should turn his gaze mainly forwards; but his knowledge and interests gradually widen, as he gains the tools for attack on more and more varied problems, one leading to another. Generally a time comes when he wishes to get some picture of the tree of knowledge—at least of his particular tree—as a whole; he learns not only what the pioneers of his subject did, but in what circumstances and in what intellectual atmosphere they did it. Such a man can attain a better understanding of the history of his subject than a historian who studies science without having contributed to it; but the aid of the historian, with his knowledge of the sources, is of great value to his scientific colleagues.

Geomagnetism, in particular, turns the gaze of its students to the past, when they seek knowledge of its second great unsolved problem, namely, the secular variation. It was this path that led me to wish to know more of Halley and his forerunners; my interest in the history of geomagnetism developed late and slowly, and it was at the suggestion of my colleague, Dr. Julius Bartels, that a historical chapter was added

to our book "Geomagnetism." *Inter alia* this Chapter drew attention to the valuable collection of old writings and charts on meteorology and geomagnetism, reprinted by Dr. G. Hellmann.

This distinguished scientist and historian of science laid his colleagues under a great debt of gratitude by his beautiful reprints in facsimile, and by the interesting and learned Notes which he added in editing them. They were published in 12 parts, from 1893 to 1899, and are to be found in many libraries throughout the world; but doubtless there are many persons concerned with geomagnetism who would find pleasure and interest in these reprints, who have never seen them and have no easy access to them. Moreover many of these writings are in languages other than English, and in some cases in old forms of language not now easily understood even by countrymen of the authors.

These considerations led me to suggest to the Editor of the *Journal of Terrestrial Magnetism and Atmospheric Electricity*, Dr. J. A. Fleming, in January 1941, that "a new and useful departure" would be to include in the JOURNAL, from time to time, a Section under the general title *Archaeologica Geomagnetica*, and containing historical articles and reproductions of the old classics of the subject, in facsimile or otherwise, either in the original languages or in translation. Such a Section would add pleasant variety to the JOURNAL, and would arouse and maintain the interest of many readers in the history of the subject. The inclusion of the old writings, in a continuing publication, would also increase the chance of their coming to the notice of future readers, and would render them more easily available to such readers, particularly in view of the general and very proper desire of librarians to have complete sets of the periodicals current in their collections. Many readers like to browse in the back volumes of journals on their subject, and in this way might find in *Archaeologica Geomagnetica* a natural and easy introduction to the historical documents of the science.

Among the most interesting old documents of the science are the early magnetic maps and charts; these are few enough in number to make it feasible to reproduce them all, over a period of years. The founder and first Editor of the JOURNAL, Dr. Louis A. Bauer, was himself much interested in the history of geomagnetism, and in Number 1 of Volume 1 of the JOURNAL (January, 1896) the first isogonic chart, Halley's Atlantic Chart,* was reproduced for the first time; Dr. Bauer himself had newly discovered it in London, after the memory of it had long passed from men's minds.

The proposal for *Archaeologica Geomagnetica* found favor with the present Editor of the JOURNAL and he was fortunately able to enlist the aid of H. D. Harradon in preparing translations of some of the foreign classics of geomagnetism, reprinted by Hellmann. This issue includes the first of these translations, that of the Latin letter of Petrus de Maricourt, written in 1269 but first printed in 1558.

*This has more recently been reproduced in the books "Terrestrial Magnetism and Electricity" [Physics of the Earth, **8**, New York, McGraw-Hill Book Co. (1939)], and "Geomagnetism" [Oxford (1940)], and in *Occasional Notes of the Royal Astronomical Society* [No. 9, pp. 122-134 (1941)] where much detailed information about Halley's two charts is given. In particular, attention is drawn to the serious geographical errors in these charts, owing to the lack, in those times, of adequate means of determining the longitude; it would be of interest to publish a map giving, in outline, Halley's land boundaries (from the World Chart), and also, in a different kind of line (for example, dotted) the true outlines as now known.

SOME EARLY CONTRIBUTIONS TO THE HISTORY OF GEOMAGNETISM—I

By H. D. Harradon

The writing of a detailed and comprehensive history of geomagnetism would present many difficulties, because the beginnings are almost hopelessly obscured by myths and legends and many important points are still subjects of uncertainty and controversy. Some light has been thrown on mooted questions by scholars in recent times, but much still remains to be clarified regarding the discovery of the directive power of the Earth's field and its practical application.[1]

There are, however, a number of documents which may be regarded as milestones in the development of geomagnetic knowledge and whose importance from a historical viewpoint is undisputed. Unfortunately, all these early writings have become extremely rare and the few extant copies are preserved in widely distributed libraries. In order to make them more generally available, G. Hellmann was led to reproduce, partly in facsimile, some of the more important contributions in his "Rara Magnetica" [Neudrucke von Schriften und Karten über Metorologie und Erdmagnetismus, No. 10, Berlin, Asher und Co. (1898)].

The reading of these reproductions is no simple matter not only because of difficulties inherent in deciphering the text in the case of facsimiles but also because they are written in Dutch, English, German, Portuguese, Spanish, and Latin over the period 1269-1599, hence not in the modern languages of today nor yet in the classic Latin of the age of Caesar and Cicero, but in the respective languages as they were employed in the Middle Ages when current physical concepts and nomenclature were not in vogue.

In order to make these early contributions to geomagnetism available to the readers of this Journal, an attempt will be made to publish some of the more important in translation.

The first translation, published below, is of the "Epistola Petri Peregrini de Maricourt ad Sygerum de Foucaucourt militem de magnete." This letter on the magnet was written by Pierre Pélerin de Maricourt—Magister Petrus Peregrinus de Maharn curia, Picardus—under the walls of Lucera, in Apulia, Southern Italy, during the siege of that town which terminated with its capitulation in 1269 to Charles of Anjou, King of Naples and Sicily and brother of Louis IX (Saint Louis). The surname "de Maricourt" is derived from the name of his native village in Picardy, and the title "Magister," which the author of the letter also bore, gave evidence that he had been a student and had attained scholastic honors. The name "Peregrinus" signifying pilgrim, which has sometimes been substituted for "de Maricourt," informs us that its bearer had taken part in one of the Crusades to the Holy Land,

[1]An important contribution to this subject has been recently made by A. Crichton Mitchell under the title of "Chapters in the history of terrestrial magnetism" [Terr. Mag., **37**, 105-146 (1932), **42**, 241-280 (1937), and **44**, 77-80 (1939)]: Chapter I, On the directive property of a magnet in the Earth's field and the origin of the nautical compass; Chapter II, The discovery of the magnetic declination; Chapter III, The discovery of the magnetic inclination.

since this was an honorary title commonly bestowed on those who had participated in the enterprise of freeing the Holy Sepulchre. His contemporary, Roger Bacon (circa 1214-1294), refers to him as the greatest experimental scientist of his time, preeminent in mathematics, and expert in the theory and practice of the technical and military arts.[2]

It is regrettable that we know so little about the author of this letter. We gather from the letter itself that he intended to write or did write other works on physics, as for example, a "Tract in which we shall show how to construct physical instruments" (I, Chapter I) and a "Book on the action of mirrors" (II, Chapter II). These documents, if ever written, have not come down to us.

The letter was addressed to his friend Sygerus de Foucaucourt,[3] "who was not a philosopher like himself, not even a scholar, but a knight . . . . and his nextdoor neighbor at home."[4] It is, according to Hellmann, "the oldest occidental treatise on magnetism and at the same time one of the earliest evidences of the beginnings of experimental investigation in the Middle Ages."

The history of the "Epistola" is of interest and there is accordingly given below the substance of Hellmann's remarks in this connection. Copies of de Maricourt's letter had a rather wide circulation[5] and it was much read until the second half of the sixteenth century although by that time further progress in terrestrial magnetism had already been made. The letter was also very well known in Germany. The physician and scientist Amplonius Ratinck of Erfurt possessed, at the beginning of the fifteenth century four different copies of which three are still preserved. A century later Georg Hartmann of Nuremburg appears to have been greatly influenced by it in his magnetic studies. The physician Achilles Pirmin Gasser of Lindau (1505-1577) also possessed a manuscript of "De Magnete" which he not only brought to the attention of his countryman Joachim Rhetoricus (before 1540) but which he had printed in 1558,* provided with an introduction and a postscript. This booklet, of which Hellmann reproduced the title-page in facsimile, has become so rare that in 1871 Prince Baldassare Boncompagne was led to ascertain how many copies there were in existence. He discovered 13, but as three escaped his notice, there were then in all at least 16 known copies, of which seven were in Germany. This same

[2]In his "Opus Tertium," Bacon expresses his admiration for Peregrinus in the following terms: "There are only two perfect mathematicians, namely, Master John of London and Master Peter of Maricourt, a Picard. . . . . I know of only one person who deserves praise for works of this science, for he does not care for discourses and verbal battles (non curat de sermonibus et pugnis verborum) but quietly pursues the works of wisdom. Therefore, though others grope blindly, like bats in the evening twilight, to see the light of the Sun, this man contemplates it in all its splendor because he is a master of experiment (dominus experimentorum). . . . . And so it is impossible to write a useful or correct treatise on experimental philosophy without referring to him." The learned friar goes on to say that if Peregrinus desired the favor of kings or princes, he would find those who would honor and enrich him, but that he neglects all honor and riches in order that he may devote himself to scientific experiments in which he takes delight.

[3]Also written Sigerus de Foucancourt, Foucancort, Fontancourt, Foncaucourt, etc.

[4]Benjamin, P. The intellectual rise of electricity, p. 168.

[5]Professor Silvanus Thompson lists 28 ancient manuscript copies of the "Epistola" written between the end of the thirteenth and the end of the sixteenth centuries. Of these, 26 were in public libraries or university collections; the remaining two were in his possession. All are in Latin except three, two of which are in Italian, and one, a late version, in English. These manuscripts are of very unequal values and no two have been found to agree precisely in their text [Proc. Brit. Acad., pp. 381-382 (1906)].

*The title-page of this edition is reproduced in Plate 1. A free translation of the title-page is as follows: "The book of Petrus Peregrinus of Maricourt on the magnet, or wheel of perpetual motion. Now published for the first time by Achilles P. Gasser L. under the auspices of the Divine Ferdinand, Emperor of the Romans. Augsburg in Swabia. In the Year of Redemption 1558."

pamphlet was even the cause of a plagiarism committed by one Jean Taisnier (or Taisner), who published in 1562 an "Opusculum perpetua memoria dignissimum de natura magnetis . . . ." which corresponds almost word for word with the "Epistola" without mentioning de Maricourt or its publisher Gasser.

Regarding the subsequent fate of the "Epistola," the following facts should be mentioned. In the year 1681 M. Thévenot believed that he could assume, from a manuscript which he had seen bearing the title "Epistola Petri Adsigerii, in super rationibus naturae magnetis," that the magnetic declination had already been discovered in 1269 (with the value of 5°). Not until 1835 did W. Wenckebach show that a marginal note of later date in the Leiden manuscript of the "Epistola" had been the cause of this error of Thévenot. In 1868, T. Bertelli showed even more conclusively that none of the other manuscripts contained this note. The other error introduced into the literature by Thévenot, of assuming a Petrus Adsigerius as the author of the "Epistola" has, despite the labors of Wenckebach and Bertelli persisted almost to our day; an unwitting copyist had written *Adsigerius* instead of *ad Sigerum*.

After T. Cavallo had published in 1795 several fragments of the Leiden codex of the "Epistola" and G. Libri had published in 1838 the Parisian manuscript of the same, Bertelli brought out in 1868 a critical text-edition based on a comparison of nine manuscripts with variants and a copious commentary. Hellmann based his "Neudrucke" on this revised text, with some dozen improvements communicated later (1871) by Bertelli.

The most important results in magnetic theory which de Maricourt communicated to his friend concern the recognition of the two unlike poles, the distribution of the magnetic field, the attraction of unlike poles, and the improvement of the mariner's compass. The idea of a magnetic perpetual-motion apparatus presented at the end of the letter was an error for which we must hold the century rather than the author himself responsible. There is a good exposition of the contents of the "Epistola" in Park Benjamin's "The intellectual rise of electricity" [London (1895)]. This author, however, goes too far in his admiration of de Maricourt, since he regards all theories on magnetism which are mentioned in the letter as discoveries of its author, whereas there can be no doubt that many of these facts were already known. This is indicated by the similarity of ideas on the magnet which are found among scientists who lived before or contemporaneously with de Maricourt, such as Vincent de Beauvais, Albertus Magnus, Roger Bacon, and Jean de S. Amand.

There exist at least two English translations of the letter, one by Sylvanus P. Thompson, printed in the Caxton type by the Chiswick Press [London (1902)], limited to 250 copies intended for private circulation. The other was by Brother Arnold (Joseph Charles Mertens) with an introduction by Brother Potamian (M. F. O'Reilly), [60 pp., New York, (1904)]. Although the former is based on a somewhat different original, considerable assistance has been derived from it in the preparation of this translation.

THE LETTER OF PETER PEREGRINUS DE MARICOURT TO SYGERUS DE FOUCAUCOURT, SOLDIER, CONCERNING THE MAGNET

This treatise on the magnet contains two parts, of which the first is complete in ten chapters and the second in three. Part I, Chapter I describes the scope of the work; Chapter II shows what an investigator in this subject ought to be; Chapter III pertains to how the stone may be recognized; Chapter IV is on how to find the parts of the stone; Chapter V concerns how to determine the poles in the stone, which pole of the stone is the north and which is the south; Chapter VI tells how one magnet attracts another magnet; Chapter VII is on how iron touched by a magnet turns towards the poles of the world; Chapter VIII describes how a magnet draws iron; Chapter IX concerns why the northern part attracts the southern and conversely; Chapter X is on how the magnet receives the natural virtue which it possesses.

The chapters of the second part are as follows: The first is on the construction of an instrument by which may be ascertained the azimuth of the Sun and the Moon, and of any star on the horizon; the second deals with the construction of another better instrument for the same purpose; and the third is on the art of the construction of a wheel for perpetual motion.

Part I

Chapter I: On the scope of the work—Most intimate of friends, at your request I shall explain in familiar language a certain hidden virtue of the lodestone. For indeed nothing has been pleasing to philosophers without a principle[6] of knowledge to explain it, because the nature of good things lurks and is obscured in darkness until it is brought to light by public discussion. Out of affection for you, therefore, I shall write down, in simple language, that which is wholly unknown to the majority of students. Nevertheless, we shall communicate in this letter only information regarding the manifest properties of the lodestone, because this information will form part of a treatise in which we shall show how to construct physical instruments. A discussion of the occult properties of this stone involves the art of stone-engraving. And although I venture to call these actions, regarding which you have inquired, manifest, they will be held in no esteem and in the minds of the common people they will be regarded as illusions and fantasms because they are secrets to the layman. They will, however, be sufficiently manifest to astrologers and naturalists and will be a consolation to them just as they will also be of no small assistance to travelers who have journeyed afar. From the above, therefore, the scope of this work is clear.

Chapter II: On what the investigator of this work should be—Know then, dearest friend, that an investigator of this subject must have an understanding of nature and not be ignorant of the celestial motions. He must also be clever in the use of his hands in order that, by means of this stone, he may produce wonderful effects. For by his carefulness he will be able in a short time to correct an error which in an age he

[6]Some of the codices have *participatione* in place of *principio* thus changing the meaning to "apart from the sharing of knowledge."

could never do by his knowledge of natural sciences and mathematics, if skill were lacking in the use of his hands. For in occult matters we investigate many things by manual industry, and in general without it we are unable to bring anything to completion. Many things, however, are subject to the realm of reason, which we cannot fully investigate by the hand. From the above, therefore, it is clear what qualifications are required in an investigator of this subject.

Chapter III: On the recognizing of the stone—This stone is recognized by four different characteristics, namely, color, homogeneity, weight, and virtue. Its color should be that of iron, livid, mixed with indigo or sky-blue, so that it resembles polished iron tarnished by impure air. I have never seen such a stone that did not have great power. Such a stone, in general, is found in northern regions, and is reported by sailors in all ports[7] of the northern seas, as for example, of Normandy, Picardy, and Flanders. Now this stone should be homogeneous in substance, since one having reddish spots or holes in places is not the best. Rarely is a magnet found without such defects. A stone, however, which is heavy on account of its homogeneity and the good compactness of its component parts is of greater value. But its virtue is recognized by its strong attraction for iron and its great weight (regarding the manner of attraction, I shall speak below). When, therefore, you find a stone with these characteristics, get it if you can. It is therefore clear by what marks this stone is recognized.

Chapter IV: On the science of finding the parts of the stone—You must know that this stone bears in itself a likeness to the heavens (the method of proving this I shall show below). And just as there are two points in the heavens more noteworthy than all the others because the celestial sphere turns about them as upon axes, one of which is called the arctic or north pole and the other the antarctic or south pole, so also in this stone, you should clearly understand that there are two points, one north and the other south. You may arrive at the general determination of these two points in various ways. One way is to round the stone with an instrument just as crystals and other stones are rounded, and then let a needle or elongated piece of iron, slender like a needle, be placed on the stone, and a line be drawn along the length of the iron dividing the stone in the middle. Then let the needle or iron be placed in another position on the stone and mark the stone with a line in the same manner according to that position. And if you wish you may repeat this in many places or positions, and there is no doubt that all the lines of this (stone) will converge in two points just as all the meridian-circles of the globe meet in the two opposite poles of the world. Know then that one is north and the other south, the proof of which you will find in the following chapter.

There is another better way of finding these points, namely, that you note the place on the rounded stone, as has been described, where the end of the needle or of the iron clings more frequently or with greater force. For this place will be one of the points determined by the method already described.

In order, therefore, that you may determine one point on the stone exactly, break from the needle or iron a little piece which shall be oblong

[7]Hellmann has here *partibus* but *portibus* was adopted by Bertelli in his critical text of 1868.

and about as long as two finger-nails and place it on the spot at which, as already stated, the point has been found, and if it stands perpendicular to the stone, there is no doubt that the place sought is there; if not move it about until it does stand perpendicular. When this has been done mark the point there; and in a like manner you will find the opposite point on the opposite side of the stone. If you do this rightly and the stone is homogeneous and select, the points will be diametrically opposite each other just as are the poles of a sphere.

Chapter V: Regarding the science of finding the poles in the stone; which of them is the north and which the south—Having noted the art of recognizing the poles of the stone in a general way, you will know in the following manner which is the north and which is the south pole. Take a round wooden vessel in the form of a cup or platter and place the stone therein so that the two poles thereof are equidistant from the side of the vessel. Then place the vessel containing the stone in another large vessel filled with water, so that, in the first vessel, the stone may be like a sailor in a ship. Let the first vessel have plenty of room in the second, just like a boat floating in a river, and I insist on plenty of room in order that the free motion of the stone may not be impeded by the contact of the small vessel against the side of the large vessel. For this stone, thus placed, will turn its small vessel about until its north pole will stand in the direction of the northern point of the heavens and the southern in the direction of the southern point. And indeed if it is moved aside a thousand times, it will return a thousand times to its position by the will of God. And since the northern and southern parts are known in the heavens, those in the stone will also be known by them, because each part of the stone will turn towards the corresponding part of the heavens.

Chapter VI: How one magnet attracts another magnet—Having discovered which is the north and which the south pole of the stone, indicate the poles with incisions so that you may recognize them as often as necessary. And if afterwards you wish to see how one stone attracts another, you will arrange two stones, prepared as has been described, in the following manner. Place one in its vessel so that it may float just like a sailor in a ship. Let the points, already found, be equidistant from the horizon or edge of the vessel, which is the same thing. But hold the other stone in your hand. Present the northern part of the stone which you are holding, to the southern part of the stone floating in the vessel; for the floating stone will follow the stone which you hold, as if wishing to adhere to it. And if, on the contrary, you bring the southern part of the stone in your hand, near the northern part of the floating stone, the same thing will happen, namely, the floating stone will follow the one which you will be holding. Know then, as a rule, that the northern part in a stone attracts the southern part in another stone, and the southern part the northern. But if you do the opposite, that is, present the northern part to the northern part, the stone which you hold in your hand will appear to flee the floating stone, and if you present the southern part to the southern, the same thing will happen. And this is because the northern part seeks the southern part; wherefore it will be seen to flee the northern. And in this is a sign that the northern part will finally be united with the southern.

Conversely, however, the same will take place in respect to the other part, that is, the southern part, because if it is presented to the southern part of the floating stone, you will see it flee from it; this, however, would not be the case, as has been said, if the northern part were brought near the southern. This, therefore, refutes the nonsense of certain persons who say that, if scammony[8] attracts bile by reason of the similarity between them, a magnet will accordingly attract a magnet more powerfully than iron, a fact which they suppose false, although it is true just as is confirmed by experiment.

Chapter VII: How iron, when touched by a magnet, turns towards the poles of the World—And it is known to all who have tried it that when an oblong piece of iron has touched the magnet and has been attached to a piece of light wood or to a straw and is placed on water, one end will turn towards the star which they call the nautical star, because it is near the pole; the fact being that it does not turn toward the aforesaid star but towards the pole, the proof of which we will present in its own chapter; but the other end will turn towards the opposite part of the heavens. As to which end of the iron turns to which region of the sky, know that that end of the iron which shall have touched the southern part of the stone will turn towards the northern quarter of the sky. The contrary, however, will be the case of the iron which the northern part of the stone shall have touched, because it will turn towards the southern part of the heavens. And it is a wonderful thing for one who does not know the cause of the motions of the iron. But experience of this has proved that we have spoken the truth.

Chapter VIII: How the magnet attracts iron—If, however, you maintain that it is according to the natural appetite of the stone that it attracts iron floating or swimming on the water, take note of the northern part of the iron and bring near it the southern part of the stone, for it will follow the latter; or, conversely, hold the northern part of the stone to the southern part of the iron, for it will attract it without reluctance. If, on the contrary, you bring the northern part of the stone to the northern part of the iron, the iron will be observed to be repelled, until the southern end is attached to the same iron. And, in like manner, you will learn the same regarding the other part.

But if violence is done to the parts, namely, if the southern part of the iron which has been touched by the northern part of the stone be touched with the southern part of the stone; or that part which was touched with the southern part of the stone, which is also called the southern in the iron, be joined to the southern part of the stone, the virtue in the iron will be easily altered, and that will become southern which was previously northern in it, and vice versa. And the cause of this is the impression of the last agent, confounding and changing the virtue of the first.

Chapter IX: Why the northern part attracts the southern and vice versa—The northern part of the stone attracts the southern and vice versa, as has been stated, in which attraction the stone of the stronger virtue is the agent and that of the weaker the patient. I think the cause

[8]A plant of the genus *convolvulus*, used as a cathartic. The original text of this sentence is as follows: Ex hoc evacuatur quorumdam fatuitas dicentium quod si scamonea choleram, ratione similitudinis, attrahat, ergo magnes magnetem, magis quam ferrum, attrahet quod falsum supponunt, cum sit verum sicut patet experimento.

of this phenomenon may be explained in this way; for the active agent strives not only to join its patient to itself but to unite with it, so that out of the agent and the patient there may be made one. And this you can find out in the case of this marvelous stone in this manner. Take one stone which you may call by AD, in which A is the north and D the south point. Divide it into two parts so that two stones are made from it. After this, place the stone which contains A on water so that it may float; you will see that A turns towards the north as before. For breaking does not take away the properties of the parts of the stone, if it is homogeneous. Hence the part of this stone at the point of fracture which is B, must be the south. Let, then, this stone regarding which we have just been speaking be represented by AB; as to the other stone, which contains D, if it is placed on water, you will see that D is south as at first, because it turns towards the south, if placed on water. But the other part near the fracture, which may be designated by C, will be the northern; this stone will therefore be CD; let the first stone AB be the agent, CD the patient, and thus you see that the two parts of the two stones which, before the separation, were continuous in one stone, after the separation, were found to be, one the northern and one the southern part. But if the same parts are again brought together, one will attract the other until they are joined together at the point BC, where the break took place. Thus by the natural appetite, they will form one body as at first. An indication of this is that if they are cemented at that point, they will exhibit the same operations as at first.

The active agent therefore, as you see by this experiment, strives to unite its patient to itself, but this is done because of the similitude between them. It is necessary, therefore, when B is united with C, by force of attraction, that there be one line made of the agent and patient, following the order $ABCD$, so that BC is one point. For in this union is retained or preserved the identity of the extreme parts just as they were at first. For A is northern in the whole line, just as it was in the divided line; in the same way D is the south point just as it was in the divided passive part, so is it in the same united: B and C therefore become one and the same.

And in the same manner, it happens that if A is joined with D, that two lines become one, by virtue of the very attraction according to this order $CDAB$, so that DA is one point; then the identity of the extreme parts will remain, just as at first, before they were united; for C will be the northern point, and B the southern, just as B and C were before the separation.

If it should be otherwise, however, this identity or similitude of the parts would not be conserved. For you see that if C be joined to A which is contrary to the truth as discovered, so that from these two lines one line is formed according to the order $BACD$, so that AC is in one point; D (which was the south before they were united) requires in this whole line, that B, the other end, should be the northern which before was southern; and, behold, the original identity or similitude is destroyed. But if you make B southern, as it was before they were united, it is required that D, the other part, should be the northern, although nevertheless it was the southern, and thus here neither identity nor similitude is preserved. For that which has now been converted from two into

one must be in the same species as the agent; this would not be the case, were nature to choose that impossible arrangement. But the same incongruity occurs, if you join *D* with *B*, so that there results one line according to this order, ABDC, as is obvious to one who gives the matter his consideration. For nature which tends towards being and acts in the better way, chooses the first order of action in which the identity is better preserved than in the second.

It is, accordingly, evident why the southern part attracts the northern and conversely; and why the attraction of the south by the south and the north by the north is not in accordance with nature.

Chapter X: On inquiry whence the magnet receives the natural virtue which it possesses—Certain inexperienced investigators are of the opinion that the virtue by which the magnet attracts iron, exists in the mineral regions in which the magnet is found, whence they say that though iron moves towards the poles of the world, this is only because a mine of the stone is situated in those regions. These, however, do not know that the aforesaid stone is found in many parts of the Earth, from which it would follow that it would turn towards various places on the Earth—which is false. And, moreover, they do not know that a place under the poles is uninhabitable, because half the year there is daytime and half the year there is night. Hence, it is senseless to think that a magnet could be brought to us from those regions. Besides, since the iron or stone turns to the south as well as to the north, as is obvious from what has been said, we are forced to conclude that the virtue flows into the poles of the stone not only from the north but also from the south, rather than from mineral regions. A clear sign of this is that wherever man has been, he sees that the motion of this stone is to his eye according to the position of his meridian circle. All meridian circles, however, converge in the poles of the world; wherefore from the poles of the world the poles of the magnet receive their virtue. From this it is clearly apparent that the magnetic needle does not point to the nautical star, since the meridian circles do not intersect there but in the poles. For the nautical star is always found outside the meridian circle of any region except twice in a complete revolution of the firmament. From these considerations it is manifest that it is from the poles of the heavens that the poles of the magnet receive their virtue (directive force).

You may rightly conclude that the other parts of the stone receive their influence from other parts of the heavens; so that you may suppose not only that the poles of the stone thus receive influence and virtue from the poles of the world, but also the whole stone does so from the whole heavens. I advise you to test this in the following manner: Let the stone be rounded and its poles located. Then place the stone on two sharp pivots, so that to each pole one pivot is lightly fixed in its socket in the stone, and that the stone may revolve on them without difficulty. When you have done this, ascertain whether the parts (poles) of the stone are equally balanced, by turning it lightly on said pivots, and this you shall repeat several times at different hours of the day with great care (wise industry). When you have done this, place the stone on the meridian circle on its pivots lightly fixed in the poles of the stone, so that it moves in the manner of armillaries in such a way that the elevation and depression of its poles may correspond with the elevation and depression of the poles of the heavens in the region where you may

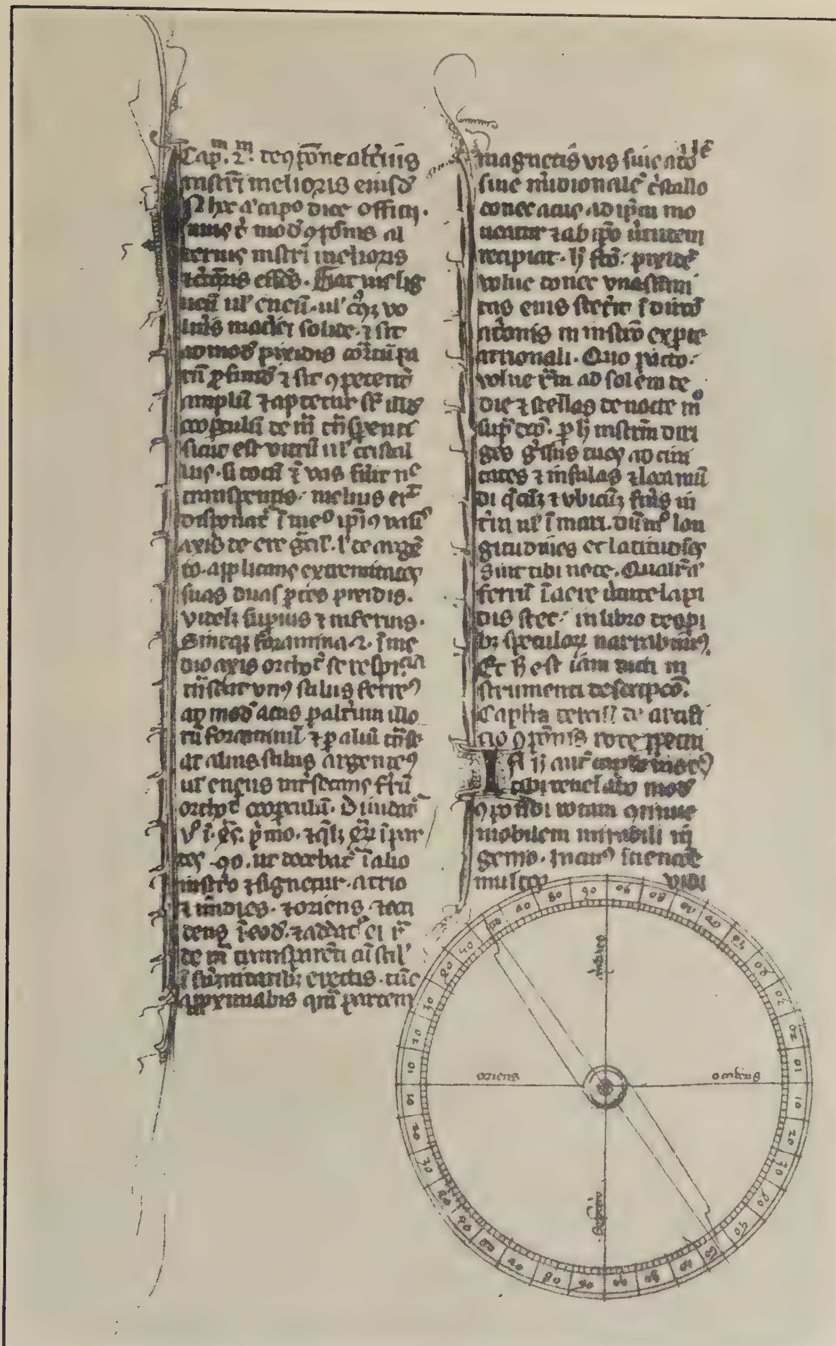
be. And if now the stone is moved according to the motion of the heavens, rejoice that you have discovered a marvelous secret, and if not, let the failure be imputed to your lack of skill rather than to a defect of nature. In this position or manner of placing, I judge that the virtues of this stone are properly conserved, and I think that in the other positions of the sky its virtue is obscured or weakened rather than conserved. By this instrument you will be freed from every kind of clock, for by it you will be able to know the ascendant in whatever hour you may wish, and all the other dispositions of the sky which astrologers seek.[9]

Part II

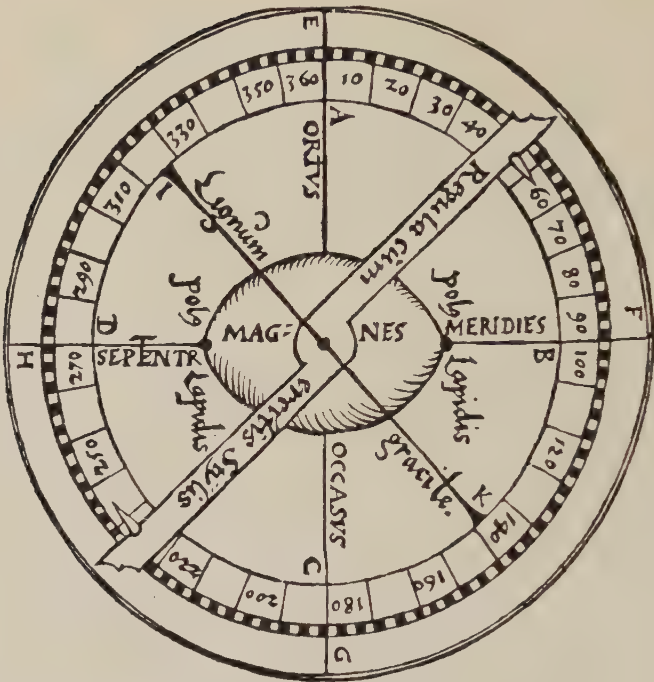
Chapter I: On the construction of an instrument by which may be ascertained the azimuth of the Sun and the Moon, and of any star on the horizon—Having reviewed the natural phenomena of the magnet, let us now proceed to the inventions which depend on a knowledge of its natural workings. Let a round magnet (terrella) be taken and its poles determined, as has been described, and let it be filed between the two poles on both sides so that the stone may be like a sphere compressed between the poles and thus occupy less space. Let this stone, thus prepared, be enclosed between two capsules (or boxes) after the manner of a mirror. And let these capsules in turn be so joined that they may not be opened later and that no water may enter. Let the capsules be prepared with cement suited to this purpose and let them be of light wood. When this has been done, place the capsules thus prepared in a large vessel full of water on the edges of which the two parts of the world, that is, the south and the north, are found and marked, and let them be indicated by a thread stretched across from the northern to the southern part of the vessel. Allow the capsules to float and let there be above them a slender strip of wood in the position of a diameter. Then move this strip of wood above the capsules until it is equidistant from the meridian line previously determined and indicated by the thread or is in the same line with it. This having been done, according to the position of the strip so situated, draw a line on the capsules; and it will be the perpetual meridional line in all regions. That line, therefore, when cut at right-angles by another, will be divided in the center and will be the line of the east and the west. And thus you will have the four quadrants actually marked on the capsules, representing the four quarters of the world, of which each should be subdivided into 90 parts so that there may be altogether 360 parts (degrees) in the entire circumference of the capsules. And inscribe divisions on it, just as they are usually inscribed on the back of the astrolabe. There shall also be a slender and light ruler above the capsules so inscribed similar to the ruler on the back of the astrolabe. In place, however, of the sights, let there be erected at right-angles two pins at the ends of the ruler.

If, therefore, you desire to have the azimuth of the Sun by day, place the capsules on water and allow them to move about until they settle in their proper position; there hold them firmly with one hand and with the other move the ruler until the shadow of the pin falls along its length; then the end of the rule on the side of the Sun will show the azimuth

[9]Per hoc autem Instrumentum excusaberis ab omni horologio; nam per ipsum scire poteris Ascensus in quacumque hora volueris, et omnes alias celi dispositiones, quas querunt Astrologi.



Facsimile of page from manuscript at the Bodleian Library of the "Epistola de Magnete" wherein is described the earliest known pivoted compass (Reproduced from "Bibliographical history of electricity and magnetism" by P. F. Mottelay)



Reproduction of illustration at end of Chapter I of Part II showing instrument for finding azimuth of Sun, Moon, or any star on the horizon (From "Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus," No. 10, by G. Hellmann)

of the Sun. If there should be a wind let the capsules be covered with some vessel until they have assumed their proper position.

At night, on the other hand, you may do the same with the Moon and stars, for you will move the ruler until the tops of the pins and the Moon or star are in the same line. For the end of the rule on the side of the star will indicate its azimuth as before.

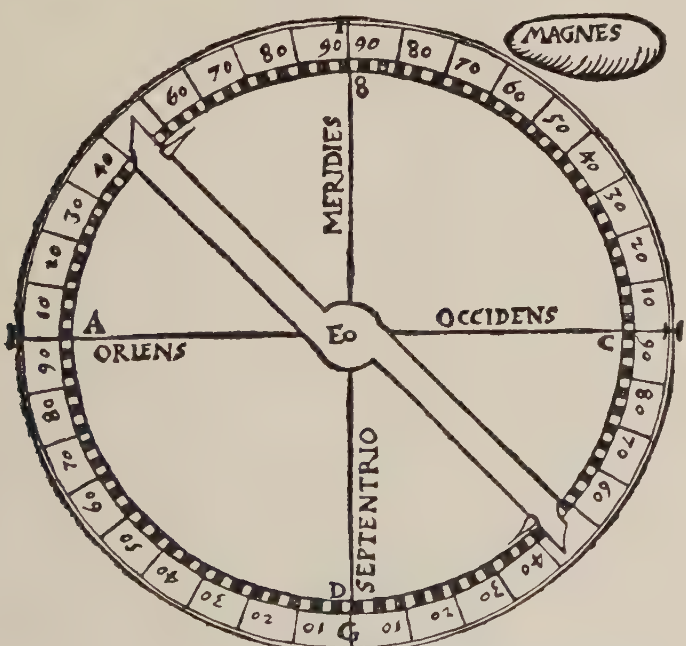
You will know, moreover, by the azimuth, the hours, the ascendants[10] and ascensions, and all things necessary according to the science of the astrolabe. The accompanying figure shows the form of this instrument.*

Chapter II: On the construction of a better instrument for the same purpose—In this chapter we shall tell you the way of constructing another instrument of better and surer effect. Let a vessel be made of wood, brass, or of any solid material that you wish, and let it be turned in the form of a jar not very deep and tolerably wide, and let it

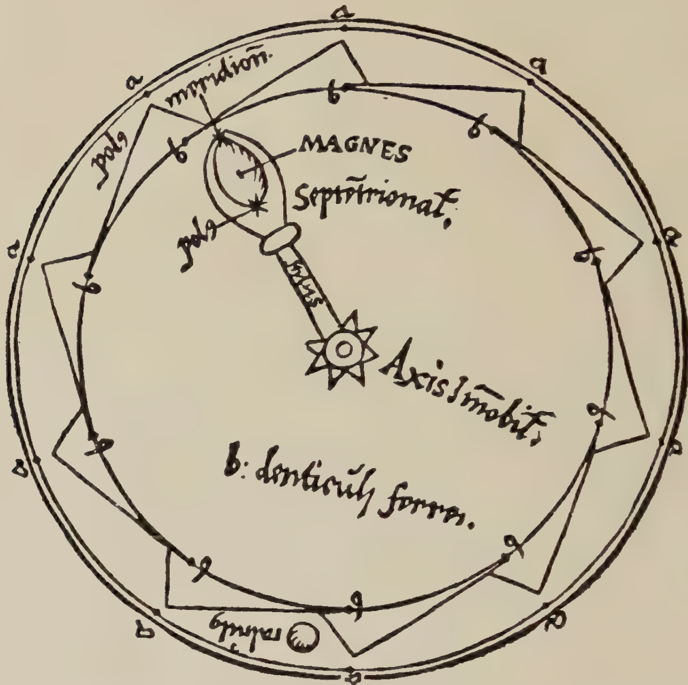
[10]Cognosces, autem, per azimuth, horas, et Ascendens, et Ascenciones, et cuncta que oportet, secundum doctrinam Astrolabii, complete. For a discussion of these terms see "A treatise on the astrolabe addressed to his son Lowys" by Geoffrey Chaucer, A. D. 1391, London, published for the Early English Text Society, by N. Trübner and Company (1872).

*Translations of legends on the three illustrations of Peregrinus' "Epistola de Magnete" at ends of chapters I, II, and III of Part II: *Magnes* =magnet; *polus lapidis* =pole of the stone; *regula cum erectis stylis* =ruler with erect pins; *ortus, occasus* =east, west; *oriens, occidens* =east, west; *septentrio, meridies* = north, south; *polus, meridion.* =south pole; *polus septentrional.* =north pole; *axis immobil.* =fixed axis; *denticuli ferrei* =iron teeth; *calculus* =pebble; *lignum gracile* =thin wooden strip.

be fitted at the top with a cover of transparent material such as glass or crystal. If the whole vessel should be of transparent material it will be better. Let there be placed in the center of the same vessel, a slender axis of brass or of silver, applying its ends to the two parts of the jar, namely, the upper and the lower. Let then two holes be made in the center of the axis at right-angles to each other, and let a piece of iron wire, similar to a needle, pass through one of the holes, and another wire of silver or of brass pass through the other, crossing the iron one at right-angles. Let the cover first be divided into quadrants and each of the quadrants into 90 parts, as was stated in the case of the other instrument. And let the north, south, east, and west be indicated on it, and let a ruler of transparent material be added to it with wires set upright at each end. You will then bring near to the crystal whatever part of the magnet you wish, whether north or south until the needle moves towards it (the magnet) and receives power from it. Having done this, turn the vessel until one end of the needle stands directly over the north of the instrument, corresponding with the northern quarter of the heavens. When this has been done, turn the rule towards the Sun by day and the stars by night, as above stated. Through this instrument you will be enabled to direct your course towards states and islands, and any places in the world, and wheresoever you may be, on land or on sea, provided that their longitudes and latitudes are known to you.



Reproduction of illustration at end of Chapter II, Part II, showing improved instrument for finding azimuth of Sun, Moon, or any star on the horizon (From Hellmann's "Neudrucke," No. 10)



Reproduction of diagram at end of Chapter III, Part II, of Peregrinus' wheel of perpetual motion (From Hellmann's "Neudrucke," No. 10)

How iron is held suspended in air by virtue of the stone, we shall explain in the book on the action of mirrors. This, then, is the description of the aforesaid instrument [see figure].

Chapter III: On the construction of the wheel—In this chapter I shall reveal to you the way to construct a continually moving wheel, of wonderful ingenuity, in the invention of which I have seen many engaged in vain attempts and wearied with much labor. For they did not perceive that they could effect the accomplishment of this by the virtue or power of the lodestone.

For the composition or construction of this wheel, construct a silver case, like that of a concave mirror, embellished with clever workmanship, with carvings and perforations which you will make both for the sake of beauty and of lightening its weight; because the lighter it is the more rapidly it will turn. You will then perforate it so that the eye of the ignorant shall not perceive what is cleverly inserted inside the cases. Let there be inside, however, small nails or teeth of iron, of one weight, inserted in the edge bent towards each other so that the distance separating them is not more than the thickness of a bean or a pea. Let the above-mentioned wheel be uniform in the weight of all its parts, then fix an axis through its center upon which the said wheel may revolve, the axis remaining quite immovable. Let a silver bar be attached to the axis and placed between the two cases, on the end of which let a

magnet be set prepared as follows: Let it be rounded and the poles found, as has been described. Then let it be shaped like an egg, with poles intact, and let it be filed somewhat in two intermediate and opposite parts so that it may be compressed and occupy less space, and that it may not touch the walls through the motion of the wheel. When it has been thus fashioned, let it be placed on the bar like a stone in a ring and let the north pole be somewhat inclined toward the small teeth of the wheel so that its virtue may flow, not diametrically but at a certain angle, into the iron teeth, so that when any tooth comes near to the north pole, and owing to the impetus of the wheel, passes a little beyond, it may approach the southern part which will flee rather than attract it, as is obvious from the rule above given. Thus every little tooth will be in a perpetual state of attraction and repulsion. And in order that the wheel may perform its duty more rapidly, insert between the cases a small round pebble of brass or silver, of such size that it may be caught between any pair of teeth; so that when the wheel is raised, the pebble may fall on the opposite side. Therefore, when the motion of the wheel is perpetual on one side, the fall of the pebble on the opposite side caught between any two of the teeth will likewise be perpetual, because, as it is drawn towards the center of the Earth by its weight, it will prove to be an assistance and will not let the teeth come to rest in a direct line with the stone. Let there be, moreover, spaces between the teeth, conveniently hollowed out, so that they may properly catch the pebble in its fall as the present figure shows. Farewell.

Completed in camp, at the siege of Lucera, in the year of our Lord 1269, eighth day of August. End of the treatise.

LETTERS TO EDITOR

(See also page 28)

SOLAR AND MAGNETIC DATA, OCTOBER TO DECEMBER, 1942, MOUNT WILSON OBSERVATORY

A small magnetic disturbance occurred on October 2-3. Only very small sunspots were visible.

Although an active sunspot-group (Mount Wilson No. 7508) large enough to be seen without a telescope, crossed the central meridian on November 2.8 GMT, 14° from the center of the solar disk, no significant terrestrial-magnetic activity was recorded while the group was visible (October 27-November 8).

Another large active group (No. 7518) crossed the central meridian on November 28.0, 6° from the center of the solar disk. Although it was slightly smaller and less active than group 7508, the Earth's magnetic field was somewhat more active while group 7518 was visible (November 21-December 3) than while group 7508 was visible.

TABLE 1—*Solar and magnetic data*

Day	October 1942						November 1942						December 1942					
	K_3						K_2						K_2					
	Whole disk	Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.	Whole disk	Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.	Whole disk	Central zone	$H\alpha$ bright	$H\alpha$ dark	No. groups	Mag'c char.
1	2	1	2	1	2	0	2	3	3	2	5	0.5	3	2	4	3	4	0
2	1	1	1	1	2	1	2	3	3	2	5[g]	0	2	1	4	2	4	0
3	1	0	1	1	1	1	3	3	3	1	3	0	2	1	3	2	4	0
4	1	1	2	1	0	0.5	3	2	3	1	3	0.5	..	..	..	..	..	0
5	1	2	2	1	2	0.5	2	1	2	1	3	0	1	1	2	1	5	0
6	2	2	2	1	0	0	2	1	2	1	3	0	1	1	2	1	3	0
7	2	2	2	1	4	0	2	0	2	2	3	0	1	1	2	0	4	0
8	1	1	2	1	4	0	1	0	1	2	3	0.5	..	..	..	..	3	0
9	1	1	2	1	4	0	1	1	1	2	3	0	1	1	2	1	2	0.5
10	2	0	2	1	4	0.5	1	1	2	1	3	0	1	1	2[d]	1	3	0.5
11	2	0	2	1	3	0.5	1	1	2	1	2	0	1	2	2	1	3	0.5
12	1	1	1	1	2	1	1	1	2	1	2	0.5	1	1	2	1	3	0
13	1	1	2	1	1	0.5	1	1	1	1	2	0	1	1	2	1	3	0
14	1	1	2	1	1	0.5	1	0	1	1	2	0.5	1	1	2	1	3	0
15	2	2	2	1	1	0.5	..	..	..	..	1	0	1	1	1	1	3	0
16	2	2	2	1	1	0.5	1	0	1	1	0	0	1	1	1	1	3	0
17	1	1	1	1	1	0.5	1	0	1	1	0	0	..	..	..	..	2	0
18	1	0	1	1	2	0.5	1	1	1	1	0	0	1	1	1	1	1	0
19	1	0	1	1	2	0.5	..	..	..	..	0	0	1	1	1	1	0	0
20	1	0	1	2	2	0	1	1	1	1	1	0.5	1	1	1	2	3	0
21	1	1	2	1	2	0	1	1	1	1	3	0	1	1	2	2	2	1
22	1	1	2	1	4	0	1	1	1	1	3	0	2	1	2	1	2	0.5
23	2	2	2	1	2	0	2	2	..	..	4	0.5	2	1	2	2	4	0.5
24	2	2	2	1	3	0	2	1	2	1	3	1	..	..	..	..	..	0
25	2	2	2	1	1	0.5	2	1	2	1	5	0.5	..	..	..	..	2	0.5
26	2	2	2	2	2	0	2	1	3	1	6	0.5	3	3	3	2	2	0.5
27	..	..	..	..	3	0	3	2	3	1	7	0.5	3	3	3	2	1	...
28	..	..	..	..	..	0	2	3	3	2	5[f]	0.5	3	3	3	2	1	0
29	2	1	2	2	5	0.5	3	3	3	2	5[a]	0	2	1	3	2	1[f]	0
30	2	1	2	1	5	0.5	..	..	..	..	5[f]	0	2	1	3[c]	2	1	0
31	2	1	2	1	5	0.5							1	1	2	2	2	0
Mean	1.5	1.1	1.8	1.1	2.4	0.3	1.7	1.3	1.9	1.3	3.0	0.2	1.5	1.3	2.2	1.5	2.6	0.2

NOTE—For an explanation of these tables see this JOURNAL, 35, 47-49 (1930).

The character-figures of solar phenomena are estimated from the spectroheliograms which are made with a 2-inch solar image, usually in the early morning. Very bright chromospheric eruptions are reported in these notes if observed at any time during the day.

[a, b] Formation of a new group which later developed to average size or larger; (*a*) less than 30° from the center of the disk, (*b*) more than 30° from the center of the disk.

[c, d] Very bright chromospheric eruptions; (*c*) less than 30° from the center of the disk, (*d*) more than 30° from the center of the disk.

[e, f, g, h, i, j, k, l] Passage of a large or active group across the central meridian within 5°, 10°, 15°, 20°, 25°, 30°, 35°, 40° of the center of the disk, respectively.

AMERICAN MAGNETIC CHARACTER-FIGURE, C_A, THREE-HOUR-RANGE INDICES, K, AND MEAN K-INDICES, K_A, FOR OCTOBER TO DECEMBER, 1942, AND SUMMARY FOR YEAR 1942

By H. F. Johnston

Summaries of American *URSI* broadcasts have appeared regularly in this Journal since the issue for December, 1930.

As set forth in this Journal for June, 1937, "The Department of Terrestrial Magnetism and the United States Coast and Geodetic Survey with the cooperation of the United States Army and the United States Navy communication-services and several amateur radio stations have undertaken to supply the American character-figure based upon the reports of the seven American-operated observatories—those of the Department of Terrestrial Magnetism at Huancayo in Peru and at Watheroo in Western Australia, and those of the United States Coast and Geodetic Survey at Cheltenham (Maryland), Honolulu (Hawaii), San Juan (Puerto Rico), Sitka (Alaska), and Tucson (Arizona)." This character-figure is being designated C_A, and its values for the first twelve, the second twelve, and all twenty-four hours of each Greenwich day for October to December, 1942, are given in Table 1.

From April 6, 1940, to November 28, 1941, American *URSI* broadcasts gave three-hour-range indices, K, for each of the seven American-operated observatories. Since November 28, 1941, the indices have been supplied by the Department of Terrestrial Magnetism in "Weekly reports on geomagnetic activity" directly to organizations or individuals with legitimate needs which are compatible with the War emergency. The eight indices for each day give geomagnetic activity for three-hour periods successively during the Greenwich day. The indices range from "zero" very quiet to "nine" extremely disturbed. The K-indices for Sitka (Si), Cheltenham (Ch), Tucson (Tu), San Juan (SJ), Honolulu (Ho), Huancayo (Hu), and Watheroo (Wa), for October to December, 1942, are given in Table 2. Interpolated indices are shown thus: $\ddot{3}$.

In the manner set forth in the Journal for September, 1940, the indices are standardized into reduced indices K_r to eliminate local variations. A weighted mean index, K_A, is derived from the reduced indices. The reduced indices from Si, Ch, and Wa are given double weight and those from Tu, SJ, Ho, and Hu are given single weight. The weighted indices, K_A, for October to December, 1942, are given in Table 3. A superior cross ($^\times$) following an index-number denotes a half-unit, thus $5^\times = 5.5$, etc.

The mean ratings of the American magnetic character-figure for each Greenwich half-day by months during 1942, for the individual observatories, appear in Table 4. The average activity for the year, 0.41, does not materially differ from those for the years 1937 to 1941

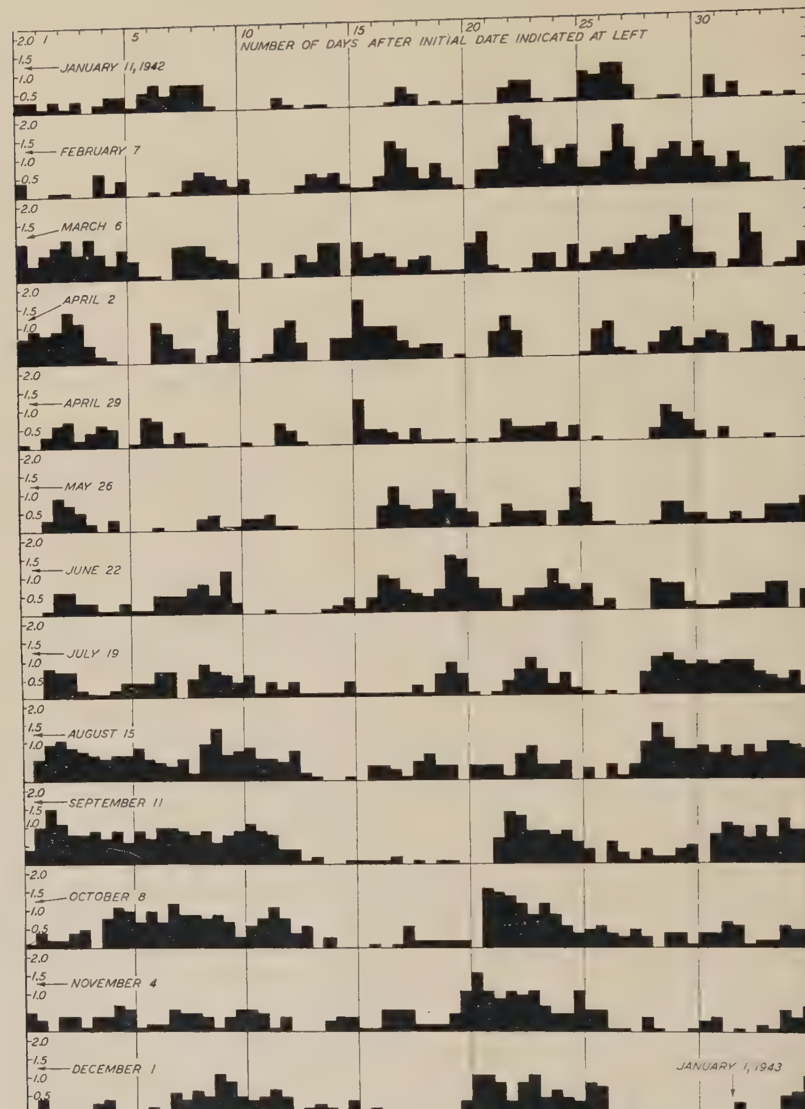


FIG. 1—AMERICAN CHARACTER-FIGURE, C_A, GREENWICH HALF-DAYS IN 27-DAY SEQUENCES, JANUARY 11, 1942, TO JANUARY 4, 1943

which are 0.36, 0.38, 0.40, 0.38, and 0.40, respectively. C_A for each half-day of the period from January 11, 1942, to January 4, 1943, is plotted in Figure 1 arranged according to 27-day sequences. With the decline of the sunspot-cycle, the recurrence of both quiet and disturbed periods at 27-day intervals was more marked. There were seven returns of the quiet period from August 1 to 5 and six of the disturbed period

TABLE 1—*American magnetic character-figure C_A for Greenwich half- and full-days based on reports from Cheltenham, Honolulu, Huancayo, San Juan, Sitka, Tucson, and Watheroo for October to December, 1942*

Day	October			November			December		
	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h
1	0.0	0.0	0.0	0.6	0.4	0.5	0.0	0.4	0.2
2	0.7	1.4	1.1	0.5	0.6	0.6	0.1	0.0	0.0
3	1.3	0.9	1.1	0.4	0.3	0.3	0.0	0.1	0.1
4	0.9	0.8	0.9	0.5	0.3	0.4	0.3	0.4	0.3
5	0.9	0.6	0.8	0.0	0.4	0.2	0.0	0.1	0.0
6	0.4	0.1	0.2	0.4	0.1	0.2	0.0	0.2	0.1
7	0.6	0.3	0.4	0.4	0.4	0.4	0.1	0.6	0.4
8	0.1	0.4	0.2	0.7	0.6	0.7	0.4	0.7	0.5
9	0.2	0.2	0.2	0.1	0.2	0.1	0.5	1.1	0.8
10	0.4	0.5	0.4	0.2	0.6	0.4	0.9	0.5	0.7
11	0.0	0.8	0.4	0.5	0.5	0.5	0.4	0.5	0.5
12	1.1	1.0	1.1	0.4	0.1	0.2	0.7	0.5	0.6
13	0.7	1.0	0.9	0.4	0.6	0.5	0.0	0.2	0.1
14	0.7	1.2	1.0	0.6	0.5	0.5	0.3	0.2	0.2
15	0.9	0.9	0.9	0.1	0.4	0.3	0.0	0.4	0.2
16	0.8	0.9	0.8	0.0	0.0	0.0	0.1	0.2	0.1
17	0.7	0.3	0.5	0.0	0.3	0.1	0.0	0.1	0.0
18	0.6	0.8	0.7	0.4	0.4	0.4	0.0	0.0	0.0
19	1.1	0.8	0.9	0.1	0.1	0.1	0.0	0.0	0.0
20	0.4	0.6	0.5	0.6	0.6	0.6	0.1	0.4	0.3
21	0.0	0.3	0.1	0.6	0.2	0.4	1.1	1.1	1.1
22	0.0	0.0	0.0	0.0	0.2	0.1	0.9	0.4	0.6
23	0.0	0.1	0.0	0.5	1.1	0.8	0.9	1.1	1.0
24	0.0	0.1	0.0	1.6	1.1	1.4	0.5	0.7	0.6
25	0.6	0.2	0.4	0.9	1.1	1.0	0.5	0.4	0.4
26	0.2	0.2	0.2	1.0	1.1	1.0	0.9	0.8	0.9
27	0.2	0.2	0.2	0.7	0.5	0.6	0.1	0.1	0.1
28	0.0	1.6	0.8	0.5	1.1	0.8	0.1	0.0	0.0
29	1.5	1.4	1.5	0.6	0.6	0.6	0.0	0.1	0.0
30	1.2	0.9	1.1	0.1	0.1	0.1	0.0	0.0	0.0
31	1.2	0.9	1.0				0.0	0.0	0.0
Means	0.6	0.6	0.6	0.4	0.5	0.5	0.3	0.4	0.3

from August 7 to 11. There were many periods of a few days' duration when both quiet and disturbed conditions recurred from two to five times.

Daily indices *B*, given to half-units, and derived from the weighted indices in the manner outlined on pages 441-442 of the December 1939 issue of this JOURNAL are given in Table 5 for the year 1942. Eight indices are given for each date, for 24-hour periods starting every three hours of the Greenwich day.

The first *B*-index entered against each date refers to the *ordinary Greenwich day*, starting at Greenwich mean midnight; the second, third, ..., eighth indices refer to the 24 hours beginning at 3^h, 6^h, ..., 21^h GMT for the same Greenwich date. If indices for *local days* (starting

Table 2--Three-hour-range indices, K, October to December 1942

October 1942

	1	2	3	4	5	6	7	8
Si	1001 1111	2124 7653	4756 4532	3555 6533	3455 5411	2331 0011	3452 4311	2223 2131
Ch	1100 0122	2223 5453	6644 4444	4543 3334	4543 4223	3232 0013	4451 2112	3311 1132
Tu	1100 0221	3233 5554	5555 5433	4545 4443	4543 4322	3232 0113	5441 3213	4312 2232
SJ	0101 0101	3223 4353	5433 3333	3433 4233	3323 3113	2222 0122	3343 2112	3201 1032
Ho	1100 0011	3244 5442	4544 3322	2434 3312	2442 4222	2131 0012	3231 3211	2101 2112
Hu	1101 2321	3234 6653	3332 4533	3332 3433	3322 3322	2110 1212	3210 3221	2201 2331
Wa	1111 1211	2234 6553	3544 4433	3444 5523	3343 5422	3122 1122	3222 4323	2211 3332

	9	10	11	12	13	14	15	16
Si	2422 2220	0122 1122	1003 3232	4446 7333	4433 4543	3445 6644	2554 4333	4344 6332
Ch	4422 1121	1222 2223	2002 2253	5535 4334	4433 4544	5333 4545	3542 3345	5332 4333
Tu	3322 2221	1233 2233	2113 3344	5436 5444	4434 3544	4433 4555	3543 3244	5333 3332
SJ	3320 2131	1123 2332	2002 2353	3325 3243	4322 3543	3322 3445	3422 2243	4223 3332
Ho	1221 1131	1232 2222	1102 3242	4225 4223	2223 2323	3233 3233	3432 3233	3223 3222
Hu	2321 2231	1222 4332	2112 3353	3324 4432	3212 5533	3222 4444	3412 4343	4213 4442
Wa	2112 2221	2343 2223	2212 3344	4326 6544	4324 4534	4434 5544	2542 3443	4323 4342

	17	18	19	20	21	22	23	24
Si	3533 2321	2444 3443	4355 6532	2334 5511	2131 2321	0012 2100	0033 2011	0000 0110
Ch	4432 3233	2432 2343	5553 4433	4322 3321	2221 2322	2200 1111	1022 1011	0001 1110
Tu	3532 2122	2442 3333	6553 4322	3323 4321	2221 2321	1101 2110	0022 0011	1011 1121
SJ	3421 1122	1222 2433	5432 3222	3312 4210	0120 1211	1101 0110	0111 1110	0011 2120
Ho	2332 2222	2332 2223	4343 3222	2213 3310	1120 2201	0101 2000	0111 0001	0010 1110
Hu	2322 3332	1213 4442	4323 4532	3313 4421	1121 3321	1111 2201	0111 2221	1011 3331
Wa	2422 3322	3334 3543	3343 5533	2324 5422	2121 4422	1122 2111	1113 3321	2212 1222

	25	26	27	28	29	30	31	
Si	2332 2221	2410 1111	2222 1211	0003 7765	3778 8655	4576 6543	3555 4333	
Ch	3333 3211	3321 0123	3321 1221	0103 4546	4677 6555	6544 4333	5445 5334	
Tu	3333 3211	2320 1123	3221 2222	0103 4654	5666 5554	5554 3433	5444 4334	
SJ	2333 3221	1311 0122	2101 1211	1103 5654	4455 4544	5433 3223	4323 3323	
Ho	2333 3111	1220 0012	1121 1101	0002 4544	3455 3333	2453 2323	3343 3322	
Hu	2222 5321	1311 2322	2111 3312	0102 5765	4243 4544	4223 5533	4323 5433	
Wa	3333 3222	2321 2133	3222 1312	1223 6765	4556 6544	3344 4543	4354 5443	

November 1942

	1	2	3	4	5	6	7	8
Si	1345 3210	1335 4431	2244 4321	0145 4121	1011 2022	2203 1211	1332 4211	2245 3221
Ch	3333 2211	2423 2222	2223 2112	1244 2122	2011 1124	4302 0212	3332 2112	2334 2232
Tu	2344 2321	2434 3322	2222 2222	1244 1122	1111 1034	4312 1223	3432 2222	2434 2333
SJ	3333 2212	2322 1331	2121 2212	1234 2111	1112 1135	3201 0122	2222 2112	2333 2233
Ho	1243 1112	1233 2320	1012 2200	0234 1021	1011 2022	2210 0111	1221 2012	1243 1122
Hu	2223 4431	2212 4331	2112 3332	1123 3331	1111 3343	3211 2421	1212 4332	2233 4433
Wa	2234 3322	2323 4432	2222 4322	1223 2222	2112 2134	3322 1312	2323 4323	2343 4243

	9	10	11	12	13	14	15	16
Si	2111 2111	2122 4322	2232 4222	2442 2111	2123 3422	2353 2322	3211 2322	3021 0121
Ch	2101 1122	2122 4322	3323 3233	3331 1223	3223 3233	3443 2234	5201 1234	4111 1112
Tu	2110 1122	2122 3323	3322 3233	3432 2123	3222 2333	3454 2223	4201 1223	3211 0022
SJ	2000 1111	2112 4322	3322 3132	2221 2122	2222 4233	2331 1233	3200 1113	3111 0111
Ho	1000 1011	2012 3112	1210 3022	1231 1112	2122 2322	1232 1121	2000 0212	2010 0011
Hu	2100 3332	2122 5532	3223 4342	2211 2321	2122 5432	2323 3433	3112 3322	1112 1231
Wa	3211 2223	3122 5323	3233 4243	2232 3222	2222 5433	3232 2343	3211 3333	2212 1122

	17	18	19	20	21	22	23	24
Si	1123 4211	2143 2322	0233 3121	1215 3231	2243 3111	1022 1110	1223 4424	5679 7353
Ch	1122 2013	3132 2232	1222 1112	3323 2233	2232 2121	0011 1101	2222 3336	5556 4352
Tu	2223 3222	3132 2332	1222 1122	3323 2342	2333 2222	1011 0112	3332 3435	5666 4342
SJ	1111 2012	2122 1242	1221 0113	3323 2342	2232 1101	0001 0000	2221 2335	4545 3242
Ho	1102 3111	2122 1222	1113 1112	1123 1122	1133 1011	0000 0000	3211 3325	5555 3222
Hu	1212 3322	2221 3332	1121 2323	3323 4543	3222 3321	1011 3322	3322 4544	3233 3442
Wa	1213 3222	3223 3323	2233 1123	3335 3253	2234 2122	1111 2222	2323 4434	5555 4444

	25	26	27	28	29	30		
Si	3546 5533	3536 6543	2344 3232	2245 5443	3234 4332	1232 3221		
Ch	5434 3335	5533 3444	2335 2123	2324 3444	4223 2322	0232 3112		
Tu	4444 4435	5634 4453	2235 2243	2334 4544	4224 3312	1242 3220		
SJ	3323 2324	3423 3342	1323 2232	1223 2444	3113 1311	1122 1111		
Ho	3223 3323	4323 3343	1134 1122	2223 2323	3134 3311	0130 2111		
Hu	3213 4533	2422 4542	1222 3332	1222 4544	3212 4421	1112 3321		
Wa	3325 3434	4544 4343	2334 3233	1235 5544	3323 4332	2223 3222		

¨ Interpolated

Table 2--Three-hour-range indices, K, October to December 1942--concluded

December 1942

	1	2	3	4	5	6	7	8
Si	1021 2222	2100 0221	0000 0122	2131 4421	1101 1220	0002 2111	1103 4322	2132 4423
Ch	3111 1132	3000 0111	2000 0103	3231 3311	3201 1110	0000 1112	1213 3322	2241 1233
Tu	1021 1232	3101 0111	0000 1213	3331 3311	3201 1110	0001 1012	2113 3322	2141 2243
SJ	1011 1122	2001 1111	0001 0213	2230 2121	2100 0100	0001 1001	1101 3221	2021 2242
Ho	1010 1122	1000 0011	0000 0113	1020 2211	0000 1100	0001 1011	1001 2311	1130 1131
Hu	1011 4432	2001 2231	1001 2432	3222 4432	1101 3311	0002 2222	1102 4432	2123 3442
Wa	2211 3233	2222 1212	2211 1223	4322 4432	1222 1211	1212 2122	2322 4433	2221 3244
	9	10	11	12	13	14	15	16
Si	2213 5534	4552 2222	1424 4213	3145 5121	1020 0210	1223 2221	1100 1120	1232 2121
Ch	4422 3335	5533 2223	1423 3324	3133 3222	2111 1211	2222 2111	1200 1222	1321 1221
Tu	3313 2545	4542 2223	1524 3123	3133 3211	1011 1302	2323 2222	1210 1231	1321 1222
SJ	3322 3444	3432 2112	1312 3223	2022 2011	1001 0100	2212 2010	1200 1222	1201 1211
Ho	2123 3333	2432 1122	1313 3022	2133 2112	1000 1310	2222 1110	0100 1122	1221 1112
Hu	2213 3653	3322 2332	1312 3331	3223 3322	1001 3421	2223 4332	1101 3431	1201 3332
Wa	2223 5543	4443 3333	2324 4222	3234 4322	2111 2321	2233 3322	2222 2333	2222 2423
	17	18	19	20	21	22	23	24
Si	1011 1111	0000 0110	0021 0010	1101 0222	3336 7532	4335 4231	2276 6552	2443 4322
Ch	0111 0111	2200 0100	2221 0001	3211 0233	4434 5433	5433 3121	2355 5432	2344 3213
Tu	0111 1112	1111 1101	1121 0011	3212 0322	5544 5423	4434 2131	1345 5433	2344 3324
SJ	0110 0011	0101 1001	1011 0011	2111 0333	4324 4432	4322 2121	1234 4432	2233 3123
Ho	1110 0012	0010 0101	0010 0011	2112 0123	4334 5312	3234 2122	1244 4322	2133 3313
Hu	0111 2312	0011 3210	1011 1222	2112 2232	4322 5543	3222 4331	1233 4542	2113 4433
Wa	1122 2224	1122 2212	2112 1112	2222 2444	4545 5433	4445 3232	4445 6543	3233 4333
	25	26	27	28	29	30	31	
Si	3133 3321	2455 5422	2321 2221	1120 3120	0011 2110	1010 0010	0012 0000	
Ch	5233 3222	3543 3334	1321 1121	2310 3111	0101 2000	0100 0000	1000 0000	
Tu	4223 3222	3454 3433	2211 1122	1220 3212	0111 1111	1100 0011	1001 0000	
SJ	4122 2102	3342 2333	2211 1021	1211 0111	0000 1211	0000 0010	0000 0010	
Ho	3113 2111	3432 3322	0111 1021	1111 2101	0002 1010	1100 0001	1011 0001	
Hu	3112 3332	3232 4542	2211 3321	1111 2321	0002 2220	1001 1121	1001 1111	
Wa	3222 3323	3434 4343	2222 3122	3322 2222	2212 2322	2111 1112	1111 1112	

Table 3--Weighted average of reduced three-hour-range indices, October to December 1942

Day	October 1942									November 1942									December 1942								
	Values K_A								Sum	Values K_A								Sum	Values K_A								Sum
1	1	1	0	0^x	0^x	1^x	1	1	6^x	2^x	3	3^x	3^x	2	2^x	1^x	1	19^x	2	0^x	1^x	1	2	2	2^x	2^x	14
2	2^x	2	3	3^x	5^x	5	5	3	29^x	2	3^x	2^x	3	2^x	3	2^x	1^x	20^x	2^x	1	0^x	0^x	0^x	1^x	1^x	1^x	9^x
3	4^x	5	4	4	3^x	4	3	3	31	2^x	2	2	2^x	2^x	2	1^x	2	17	1	0^x	0	0^x	0^x	2	1^x	3	9
4	3^x	4^x	3^x	3^x	4	4	2^x	3^x	29	1	2	3^x	4	2	1^x	2	1^x	17^x	3	2^x	2^x	1	3	3	2	1^x	18^x
5	3^x	4	3^x	3	4	3	1^x	2	24^x	2	0^x	1	1^x	1^x	1	2^x	3^x	13^x	2	2	0^x	1	1	1^x	1	0^x	9^x
6	2^x	2	2^x	2	0^x	0^x	1	2	13	3^x	3	1	1^x	0^x	2	1^x	2	15	0	0^x	0	1^x	1^x	1	1	2	7^x
7	3^x	3	3^x	1^x	3	2	1	2	19^x	2^x	3	2^x	2	2^x	1^x	1^x	2^x	18	1^x	2	0^x	2	3	3	2	2	16
8	2^x	2^x	1	1^x	2	2	2^x	1^x	15^x	2^x	3	3^x	3^x	2^x	2^x	3	2^x	23	2^x	1^x	3	1^x	2	2^x	3^x	3	19^x
9	2^x	3	2	1^x	2	1^x	2	1	15^x	2^x	1^x	0^x	0^x	1^x	1^x	1^x	2	11^x	3	3	1^x	2^x	3^x	4	3^x	4	25
10	1	2	3	2^x	2	2^x	2	2^x	17^x	2^x	1	2	2	4	3	2	2^x	19	4^x	4^x	3^x	2^x	2	2	2^x	2^x	24
11	2	1	0^x	2	3	2^x	4	3	18	3	2^x	2^x	2^x	3	2	3	2^x	21	1^x	4	2	3^x	3	2	2	3	21
12	4	3^x	2^x	5	4^x	3^x	3	3^x	29^x	2^x	3	3	1^x	2	2	1^x	2	17^x	3^x	1^x	3	3^x	3	2	1^x	2	20
13	4	3	2^x	3	3^x	5	3^x	3^x	28	3	2	2	2^x	3^x	3	3	3	22	2	0^x	1	0^x	1	2^x	1	0^x	9
14	4	3^x	3	3	4	4^x	4	4^x	30^x	3	3	3^x	2^x	2	2^x	3	3	22^x	2^x	2^x	2^x	2^x	2	2	1^x	1^x	17
15	2^x	4^x	3^x	2^x	3	3	3^x	3^x	26	4	2	0^x	1	1^x	2^x	2	3	16^x	1^x	2	0^x	0^x	1^x	2	2^x	1^x	12
16	4^x	2^x	2^x	3	3^x	3	3	2	24	3	1	1^x	1^x	0^x	1	1^x	1^x	11^x	1^x	2^x	1^x	1^x	1^x	2	2	2	14^x
17	3	4	2^x	2	2^x	2^x	2	2	20^x	1^x	2	1^x	2^x	2^x	1^x	1^x	2	15	1	1	1^x	1	1	1	1	2	9^x
18	2	3	3	3	3	4	3^x	3	24^x	3	1^x	3	2	2	2^x	2^x	2^x	19	0^x	1	1	0^x	1	1^x	0^x	0^x	6^x
19	4^x	3^x	4	3	4	4	2^x	2^x	28	1	2	2^x	2	1^x	1^x	1^x	2^x	14^x	1^x	0^x	1^x	1	0	0^x	1	1	7
20	3	3	2	3	4	3^x	1^x	1	21	3	3	2	3^x	2	2^x	3^x	2^x	22	2^x	2	1	1^x	0^x	2^x	3	3	16
21	1^x	1^x	2^x	1	2^x	3	1^x	1^x	15	2^x	2^x	3	3	2	1^x	1^x	1^x	17^x	4^x	4	3	4^x	5	4	2^x	3	30^x
22	1	1	1	1	1^x	1	0^x	0^x	7^x	1	0	1	1	1	1^x	1	1	7^x	4^x	3^x	3	4	2^x	1^x	2^x	1^x	23
23	0^x	0^x	1^x	2	1^x	1	1	1	9	2^x	3	2	2	3	3^x	3	5	24	2^x	3	4^x	5	5	4	3^x	2^x	30
24	0^x	0^x	0^x	1	1	1^x	1^x	0^x	7	5	5	5^x	6^x	4	3	4^x	3	36^x	2^x	2^x	3^x	3	3	2^x	2	3	22
25	2^x	3	3	2^x	3	2	1^x	1^x	19	4	3^x	2^x	4	3	3^x	3	4	27^x	4	2	2	2^x	2^x	2	2	2	19
26	2	3	1^x	1	1	1	1^x	2^x	13^x	4	5	3	3^x	3^x	3^x	4	3	29^x	3	4	4	3^x	3	3	3	3	26^x
27	2^x	2	2	1^x	1^x	2^x	1	1^x	14^x	2	3	3	4	2	2	3	2^x	21^x	2	2^x	1^x	1	1^x	1	2	1^x	13
28	0^x	1	0^x	2^x	5	6	5^x	5	26	2	2^x	3	4	3^x	4	4	4	27	2	2^x	1^x	0^x	2	1^x	1^x	1	12^x
29	4	5	5^x	6	5^x	5	4^x	4^x	40	4	2^x	2	3^x	3	3	2	2	22	0^x	1	0^x	1^x	1^x	1	1	0^x	7^x
30	4^x	4	4	4	3^x	4	3	3	30	1^x	2	2^x	2	2^x	2	1^x	1^x	15^x	1	0^x	0^x	0^x	0	0	1	0^x	4
31	4	3^x	3^x	4	4	3^x	3	3^x	29										1	0	0^x	1	0	0	0^x	0^x	3^x

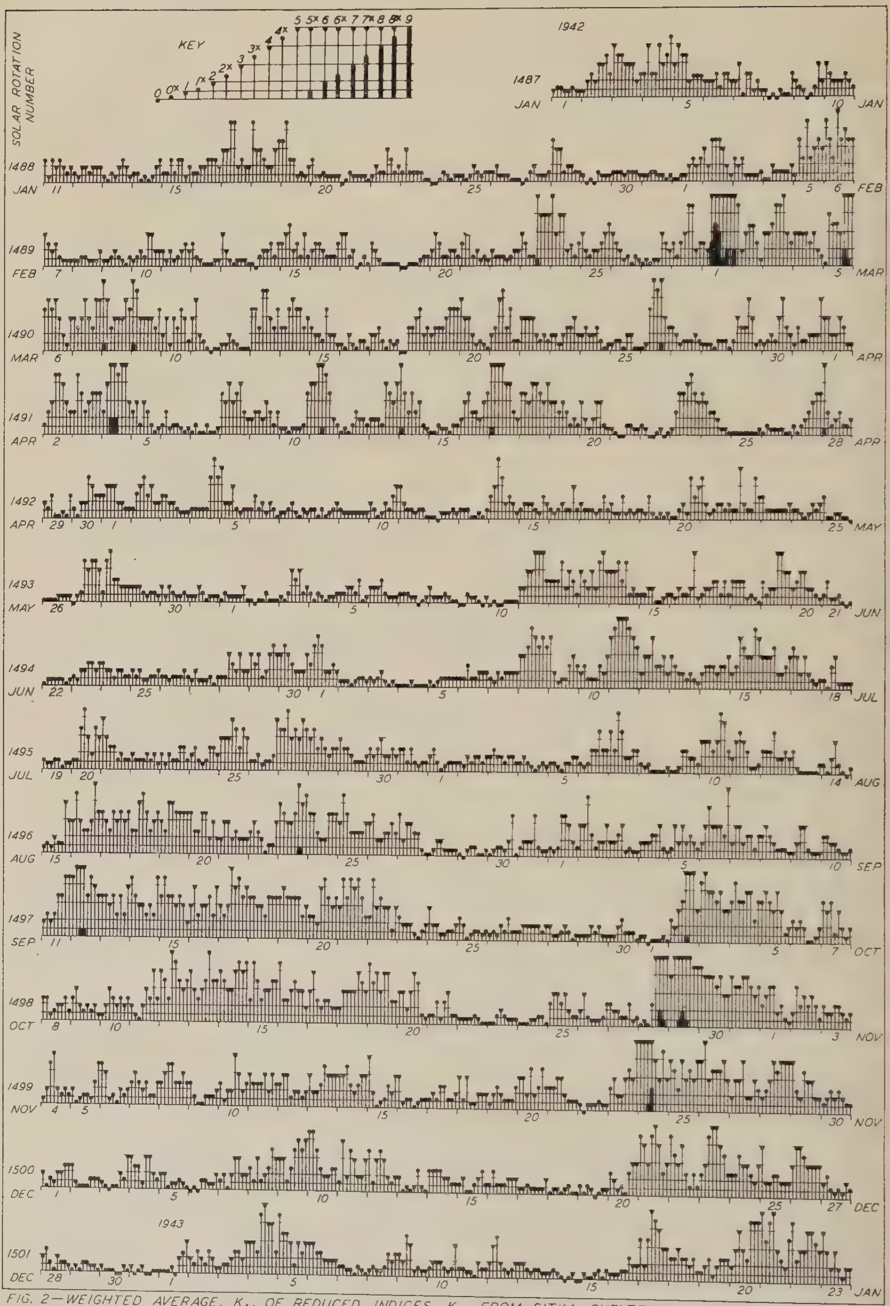


FIG. 2—WEIGHTED AVERAGE, K_A, OF REDUCED INDICES, K_r, FROM SITKA, CHELTENHAM, TUCSON, SAN JUAN, HONOLULU, HUANCAYO, AND WATHEROO, JANUARY 1, 1942, TO JANUARY 23, 1943

TABLE 4—*Mean magnetic character-figure assignments of individual observatories for half-days, 1942*

servatory	Interval GMT	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
	h h													
ltenham	0-12	0.23	0.29	0.65	0.52	0.29	0.28	0.55	0.52	0.60	0.59	0.43	0.31	0.44
	12-24	0.18	0.27	0.55	0.40	0.21	0.27	0.47	0.35	0.43	0.58	0.32	0.24	0.36
	0-24	0.20	0.28	0.60	0.46	0.25	0.28	0.51	0.44	0.52	0.64	0.38	0.27	0.40
olulu	0-12	0.26	0.32	0.69	0.53	0.35	0.43	0.53	0.52	0.67	0.61	0.53	0.32	0.48
	12-24	0.27	0.46	0.48	0.45	0.32	0.35	0.42	0.48	0.48	0.58	0.48	0.35	0.43
	0-24	0.27	0.39	0.59	0.49	0.34	0.39	0.48	0.50	0.58	0.60	0.51	0.34	0.46
ancayo	0-12	0.18	0.23	0.44	0.37	0.10	0.17	0.29	0.32	0.28	0.35	0.18	0.16	0.26
	12-24	0.42	0.43	0.61	0.53	0.18	0.27	0.34	0.32	0.40	0.65	0.60	0.42	0.43
	0-24	0.30	0.33	0.52	0.45	0.14	0.22	0.31	0.32	0.34	0.50	0.39	0.29	0.34
Juan	0-12	0.26	0.30	0.56	0.60	0.23	0.33	0.55	0.40	0.42	0.58	0.43	0.27	0.41
	12-24	0.44	0.36	0.60	0.48	0.24	0.42	0.52	0.50	0.45	0.71	0.53	0.44	0.47
	0-24	0.35	0.33	0.58	0.54	0.23	0.38	0.53	0.45	0.43	0.65	0.48	0.35	0.44
a	0-12	0.21	0.38	0.71	0.61	0.35	0.30	0.52	0.63	0.70	0.61	0.55	0.29	0.49
	12-24	0.18	0.32	0.55	0.47	0.16	0.20	0.27	0.55	0.33	0.61	0.42	0.27	0.36
	0-24	0.19	0.35	0.63	0.54	0.26	0.25	0.40	0.59	0.52	0.61	0.48	0.28	0.42
son	0-12	0.29	0.29	0.58	0.45	0.26	0.33	0.42	0.47	0.42	0.50	0.50	0.29	0.40
	12-24	0.21	0.32	0.45	0.22	0.18	0.28	0.29	0.35	0.28	0.40	0.40	0.29	0.31
	0-24	0.25	0.30	0.52	0.33	0.22	0.31	0.35	0.41	0.35	0.45	0.45	0.29	0.35
theroo	0-12	0.21	0.32	0.48	0.40	0.19	0.23	0.50	0.42	0.62	0.58	0.52	0.37	0.40
	12-24	0.27	0.36	0.61	0.45	0.26	0.32	0.45	0.53	0.60	0.81	0.73	0.55	0.50
	0-24	0.24	0.34	0.55	0.42	0.23	0.28	0.48	0.48	0.61	0.69	0.62	0.46	0.45
	0-12	0.23	0.30	0.59	0.53	0.25	0.30	0.48	0.47	0.53	0.56	0.45	0.29	0.41
leans	12-24	0.28	0.36	0.55	0.43	0.22	0.30	0.39	0.44	0.43	0.62	0.50	0.37	0.41
	0-24	0.26	0.33	0.57	0.46	0.24	0.30	0.44	0.46	0.48	0.59	0.47	0.33	0.41

at local midnight) are wanted, the first column of figures should be used for stations between 22°.5 east and 22°.5 west longitudes, the second column for stations between 22°.5 west and 67°.5 west, the third column for stations between 67°.5 west and 112°.5 west, and the fourth column for stations between 112°.5 west and 157°.5 west; the fifth column should be used, with the same local date as the Greenwich date, for stations between 157°.5 west and the date-line, and, with the local date following the Greenwich date, for stations between the date-line and 157°.5 east. Likewise, the sixth column refers to local days for stations between 157°.5 east and 112°.5 east, the seventh column to stations between 112°.5 east and 67°.5 east, and the eighth column to stations between 67°.5 east and 22°.5 east; but the index entered in the Table against *January 1*, refers, in the sixth, seventh, and eighth columns, to the local day with the date *January 2*.

The weighted mean indices, $K_{\blacktriangle}$, are shown graphically in Figure 2 from January 1, 1942, to January 23, 1943. They are arranged in solar rotations of 27 days, the last one is for solar-rotation period No. 1501 from December 28, 1942, to January 23, 1943. There were comparatively few three-hour periods when the mean index was greater than 5, namely, 1 in February, 11 in March, 6 in April, 1 in August, 2 in September, 6 in October, and 2 in November. A moderate storm took place on February 28 and March 1, mild storms on March 5, April 4, April 17, October 29, and November 24, and disturbances on February 23, March

Table 5--Daily indices, B, from weighted reduced-indices, 1942

Day	January 1942							
1	1	1	1^x	1^x	1^x	2	2	2^x
2	2^x	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
4	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x
5	3	3	2^x	2^x	2^x	2	2	2
6	2	2	2^x	2	2	2^x	2	2
7	2	2	1^x	1^x	1	1	1	0^x
8	1	1	1^x	1^x	1^x	1^x	1^x	2
9	1^x	2	2	2	2^x	2^x	2^x	2^x
10	2^x	2	2	2	2	2	2	2
11	2	2	2	2	2	1^x	1^x	2
12	2	2	1^x	1^x	1^x	1^x	1^x	1^x
13	1^x	1^x	1^x	1^x	1^x	1^x	1	1
14	1^x	1^x	1^x	1^x	1^x	2	2	2
15	2	2	2	2	2	2	2	2
16	2	2^x	2^x	3	3	3	3	3
17	3	3^x	3^x	3	3	3	3	3
18	3	3	3	3	3	3	3	3
19	2^x	2^x	2	1^x	1^x	1^x	1^x	1^x
20	1^x	1	1	1	1	1	1	1
21	1	1	1	1	1^x	1^x	2	2
22	2	2	2	2	2	2	2	2
23	1^x	1^x	1	1	1	0^x	0^x	0^x
24	0^x	1	1	1	1	1^x	1^x	1^x
25	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1
26	1	1	0^x	0^x	1	1	1	1
27	1	2	2	2^x	2^x	2^x	2^x	2^x
28	2^x	2	2	1^x	1	1	1	1
29	1	1	1	1	1^x	1^x	1^x	1^x
30	1^x	1^x	1^x	1^x	1^x	1^x	1	1
31	1	1	1	1	1	1	1^x	1^x

Day	February 1942							
1	1^x	2	2	2^x	2^x	3	3	3
2	3	3	3	2^x	2^x	2	2	1^x
3	1^x	1^x	1^x	1	1	1^x	1^x	1^x
4	1^x	1^x	2	2	2^x	2^x	3	3
5	3	3^x	3^x	3^x	3^x	3^x	4	4
6	4	3^x	3^x	3^x	3	3	2^x	2^x
7	2	1^x	1^x	1^x	1	1	1	1
8	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
9	1^x	1^x	1^x	1^x	1^x	1^x	2	2
10	2	2^x	2	2	2	2	2	2
11	2	2	2	2	1^x	1^x	1^x	1^x
12	1	1^x	1^x	1^x	1^x	1^x	1^x	1^x
13	1^x	1	0^x	1	1	1	1^x	1^x
14	1^x	2	2^x	2^x	2^x	2^x	2^x	2^x
15	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2
16	2	2	2^x	2	2	2	2	2
17	2	1^x	1^x	1^x	1	1^x	1^x	1
18	1	1	0^x	0^x	0^x	0^x	0^x	0^x
19	1	1	1^x	2	2	2	2	2
20	2	2	2	2^x	2^x	2^x	2	2
21	2	2	2	1^x	1^x	1^x	1^x	1^x
22	1^x	2	2	2	2	3	3	3^x
23	3^x	4	4	4	4^x	4	4	3^x
24	3^x	3	3	2^x	2	2	2	2^x
25	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2
26	2	1^x	1	1	1	1	1^x	1^x
27	1^x	2	2	2	2^x	3	3	3
28	3	3	3	4	5	5^x	5^x	6

Day	March 1942							
1	6	6	6	6	5^x	5	4^x	4
2	4	3	3	3	3	3^x	3^x	3^x
3	4	4	4	3^x	3^x	3^x	3	3
4	2^x	2^x	2^x	3	3	3	3^x	4
5	4^x	4^x	4^x	4^x	4^x	4^x	4	3^x
6	3	3	3	3	3	3	3	3
7	3^x	4	4	4	4	4	4	4
8	4	4	4	4	4	4	4	3^x
9	3^x	3	3	3	3	2^x	3	3
10	2^x	2^x	3	3	3	2^x	2^x	2
11	2	2	1	1	1	1	1	1
12	1	2	2	2	2^x	3	3^x	3^x
13	3^x	3^x	3^x	3^x	3^x	3	3	3
14	3	3	3	3	2^x	2^x	2^x	2^x
15	2	2	2	2	2	1^x	1^x	1
16	1	1^x	1^x	1^x	1^x	1^x	1^x	1^x
17	1^x	1^x	1	1	1^x	2	2	2^x
18	2^x	2^x	2^x	2^x	2^x	2^x	2^x	3
19	3	3	3	3^x	3^x	3	3	2^x
20	2^x	2	2	2	2^x	3	3	3
21	3	3	3	3	3	2^x	2^x	2^x
22	2^x	2^x	2^x	2	2	2	2	2
23	2	2	2^x	2^x	2^x	2^x	2^x	2
24	2	2	1^x	1^x	1^x	1^x	1^x	1^x
25	1^x	1^x	1^x	2	2^x	3	3^x	3^x
26	4	4	4	3^x	3^x	3	2	2
27	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1
28	1	1	1^x	2	2	2^x	2^x	2^x
29	2^x	2^x	2^x	2^x	2^x	2	2^x	2^x
30	2^x	2^x	2^x	2^x	2^x	2^x	2	2
31	2^x	2^x	2^x	2^x	2^x	3	3	3

Day	April 1942							
1	2^x	2	2	2^x	2^x	3	3	3^x
2	3^x	3^x	3^x	3^x	3^x	3^x	3	3^x
3	3^x	3^x	3^x	4	4^x	4^x	4^x	5
4	5	5	5	4^x	4	3^x	3	2^x
5	2	2	2	2	1^x	1^x	1^x	1^x
6	1^x	1^x	1	1	1	1	1	1
7	1	1^x	2	2^x	2^x	3	3	3
8	3^x	3	3	3	3	2^x	2^x	2^x
9	2^x	2^x	2	2	2	1^x	1^x	1^x
10	1^x	2^x	2^x	3	4	4	4	4
11	4	4	3^x	3	2^x	2	1^x	1^x
12	1^x	1^x	2	2	2	2^x	2^x	2^x
13	3	3^x	3^x	3^x	4	3^x	3^x	3^x
14	3^x	2^x	2	2	1^x	1^x	1	1
15	1	1^x	1^x	2	2	2^x	2^x	2^x
16	3	3^x	4	4	4^x	4^x	4^x	4^x
17	4^x	4	4	3^x	3^x	3^x	3^x	3^x
18	3^x	3^x	3^x	3^x	3^x	3	3	3
19	2^x	2^x	2^x	2	2	2	2^x	2^x
20	2^x	2	2	2	1^x	1^x	1	1
21	1	1	1	1	1	1	1	0^x
22	0^x	0^x	1	1^x	2	2^x	3	3
23	3^x	3^x	3^x	3^x	3^x	3	3	2^x
24	2^x	2	1^x	1^x	1	0^x	0^x	0^x
25	0^x	0^x	0^x	1	1	1	1	1
26	1	1	1	1	1	1^x	2	2
27	2^x	3^x	3^x	3^x	3^x	3^x	3	3
28	3	2	2	2	2	1^x	1^x	1^x
29	1^x	1^x	1^x	1^x	1^x	2	2^x	2^x
30	2^x	2^x	2^x	3	3	2^x	2^x	2^x

Day	May 1942							
1	2^x	2^x	2	2	2	2^x	2^x	2^x
2	2^x	2^x	2^x	2^x	2^x	2^x	2	2
3	2	1^x	1^x	1^x	1^x	1^x	2	2^x
4	3	3	3	3	3	3	3	2^x
5	2^x	2	2	2	1^x	1^x	1^x	1^x
6	1^x	1^x	1^x	1^x	1^x	1^x	1	1
7	1^x	1^x	1^x	1^x	1	1	1	1
8	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
9	1	1	1^x	1	1	1^x	1^x	1^x
10	2	2	2	2	2^x	2	2	2
11	1^x	1^x	1	1	1	1	1	1
12	1	1	1	1^x	1	1	1	1
13	1	1^x	1^x	2^x	2^x	2^x	3	3
14	3	3	2^x	2	2	2	1^x	2
15	2	2	2	1^x	1^x	1^x	1^x	2
16	2	2	2	2	2	2	2	1^x
17	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
18	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
19	1^x	1	1	1	1	1	1^x	2
20	2	2^x	2^x	2^x	2^x	2^x	2^x	2^x
21	2	1^x	1^x	2^x	2^x	2^x	2	2^x
22	2^x	2^x	2^x	2	2	2	2	2
23	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
24	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
25	1	0^x	0^x	0^x	0^x	0^x	0^x	0^x
26	1	0^x	1	1	1^x	2	2^x	2^x
27	3	3	3	3^x	3	3	3	3
28	2^x	2^x	2^x	2	2	2	2	1^x
29	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
30	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1
31	1	1	1	1	1	1	1	1

Day	June 1942							
1	1	1	1	1	1	1	1	0^x
2	0^x	0^x	0^x	1	1^x	1^x	2	2
3	2	2	2	2	2	1^x	1^x	1
4	1	1	1	1^x	1^x	1^x	1^x	1^x
5	1^x	1^x	2	2	2	2	1^x	1^x
6	1^x	1^x	1^x	1^x	1^x	1	1	1
7	1	1	1	1	1	1	1	1
8	1	1	0^x	1	1	0^x	0^x	0^x
9	0^x	0^x	0^x	0^x	0^x	0^x	0^x	0^x
10	0^x	0^x	1	1^x	2	2^x	3	3
11	3	3^x	3^x	3	3^x	3	3	2^x
12	2^x	2^x	2^x	2^x	2^x	2^x	2^x	3
13	3	3	3	3	3	3^x	3	3
14	2^x	2^x	2^x	2	2	1^x	1^x	1^x
15	1^x	1^x	1^x	1^x	1^x	1^x	1^x	2
16	2	2	2	2	2^x	2^x	2^x	2
17	2	2	2	2^x	2^x	2	2	2
18	2	2	2	1^x	1^x	2	2^x	3
19	3	3	3	3	3	3	2^x	2^x
20	2^x	2	2	2	1^x	1^x	1^x	1^x
21	1	1	1	1	1	0^x	1	1
22	1	1	1	1	1^x	1^x	2	2
23	2	2	2^x	2^x	2	2	2	2
24	2	2	1^x	1^x	1^x	1^x	1^x	1^x
25	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
26	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
27	1^x	1^x	1	1^x	2	2	2	2^x
28	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2^x
29	3	3	3	3	3	3	3	2^x
30	2^x	2^x	2^x	3	3	3	3	3

Day	July 1942							
1	3	3	2^x	2	1^x	1^x	1^x	1^x
2	1	1	1	1	1^x	1^x	1^x	1^x
3	1	1	1	1	0^x	0^x	0^x	0^x
4	0^x	0^x	0^x	0^x	1	1	1	1
5	1^x	1^x	1^x	1^x	1^x	1^x	1^x	2
6	2	2	2	1^x	1^x	2	2	2
7	2	2	2^x	2^x	3	3	3^x	3^x
8	3^x	3^x	3^x	3^x	3	2^x	2^x	2^x
9	2^x	2	2	2	2	2	2	2
10	2	2^x	3	3^x	4	4	4^x	4^x
11	4^x	4^x	4	4	4	3^x	3	3
12	3	3	3	3	2^x	2^x	2^x	2
13	2	2	2	2	2	2	2	2
14	2^x	2^x	2^x	2^x	3	3	3	3^x
15	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3
16	3	3	3	3	2^x	2^x	2^x	2^x
17	2^x	2	2	2	2	2	1^x	1^x
18	1^x	1^x	1^x	1^x	1	1	1	1
19	1	1	1	2	2^x	2^x	2^x	3
20	3	3^x	3^x	3^x	3	3	3	2^x
21	2^x	2	2	2	1^x	1^x	1^x	1^x
22	1^x	1^x	1^x	1^x	1^x	1^x	2	2
23	2	2	2	2	2	2	2	2
24	2	2	2^x	2^x	3	3	3	3
25	3	3	3	3	2^x	2^x	2	2
26	2	2^x	2^x	3	3	3^x	3^x	3^x
27	3^x	3^x	3^x	3^x	3^x	3	3	3
28	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2
29	2	2	2	2	2	2	2^x	2^x
30	2^x	2^x	2^x	2^x	2	2	2	2
31	2	2	2	2	1^x	1^x	1^x	1^x

Day	August 1942							
1	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x
2	1^x	2	2	2	2	2	2	2
3	2	2	2	2	1^x	1^x	1^x	1^x
4	1^x	1^x	1	1	1	1	1^x	1^x
5	1^x	1^x	1^x	1^x	1^x	2	2	2^x
6	2^x	2^x	2^x	3	3	3	3	3
7	3	3	2^x	2	2	1^x	1^x	1
8	1	1	0^x	0^x	1	1^x	1^x	1^x
9	1^x	2	2^x	2^x	2^x	2^x	3	3
10	3^x	3	3	3^x	3^x	3^x	3	2^x
11	2^x	2^x	2^x	2	2^x	2^x	2^x	2^x
12	2^x	2^x	2^x	2	2	1^x	1^x	1
13	1	1	1	1	1^x	1^x	1^x	1^x
14	1^x	1^x	1^x	1^x	1	1	1	2
15	2	2^x	3	3	3	3	3^x	3^x
16	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3
17	3	3	3	3	3^x	3^x	3^x	3^x
18	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x
19	3^x	3^x	3^x	3^x	3^x	3^x	3	3
20	3	2^x	3	3	2^x	2^x	2^x	2^x
21	2^x	2^x	2^x	2^x	2^x	2	2	2
22	2^x	2^x	2^x	2^x	3	3	3^x	4
23	4	4	4	4	4	3^x	3^x	3^x
24	3	3	3	3^x	3^x	3^x	3^x	3
25	3	3	3	2^x	2^x	2^x	2^x	3
26	2^x	3	2^x	2^x	3	3	3	2^x
27	2^x	2	2	2	1^x	1^x	1^x	1^x
28	1^x	1^x	1	1	1	1	1	1
29	1	1	1	1	1	1	1	2
30	2	2	2	2	2	2^x	2^x	2
31	2	2	2	2	2	2	2^x	2^x

Table 5--Daily indices, B, from weighted reduced-indices, 1942--concluded

Day	September 1942								October 1942								November 1942								December 1942							
1	2^x	2^x	3	3	3	3	3	3	1	1	1^x	2	2	3	3^x	4	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2	2	2	2	2	1^x	1^x	1^x
2	3	3	2^x	2^x	2^x	2^x	2^x	2	4	4	4^x	4^x	4^x	4^x	4	4	2^x	2^x	2^x	2^x	2^x	2^x	2	2	1^x	1	1	1	1	1	1	1
3	2	2	2	2	1^x	2	2	2	4	4	3^x	3^x	3^x	3^x	3^x	3^x	2	2	2	2^x	2^x	2^x	2^x	2^x	1^x	2	2	2	2	2^x	2^x	2^x
4	2	2	2^x	2^x	2^x	2^x	2	2^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	2^x	2^x	2^x	2	1^x	1^x	1^x	1^x	2^x	2^x	2^x	2	2	2	1^x	1^x
5	2^x	2^x	2^x	2^x	3	3	3	3	3	3	3	2^x	2^x	2	2	2	2	2^x	2^x	2^x	2^x	2^x	2^x	2^x	1^x	1	1	0^x	1	1	1	1
6	3^x	3^x	3^x	3^x	3^x	3	3	3	2	2	2	2^x	2^x	2^x	2^x	2^x	2	2	2	2	2	2^x	2^x	2^x	1	1	1^x	1^x	1^x	2	2	2
7	2^x	2^x	2^x	2^x	2^x	2^x	2	2	2^x	2^x	2^x	2	2	2	2	2	2^x	2^x	2^x	2^x	2^x	2^x	3	3	2	2^x	2^x	2^x	2^x	2^x	2	2^x
8	2	2	1^x	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2^x	2	2	2	1^x	2^x	2^x	3	2^x	2^x	3	3	3
9	2	2	2	2	2	2	2	2	2	2	1^x	2	2	2	2	2	1^x	1^x	1^x	1^x	2	2^x	2^x	2^x	3^x	3^x	3^x	4	4	3^x	3^x	3^x
10	2	2	2	2	2	2	2^x	3	2^x	2^x	2^x	2	2	2	2	2^x	2^x	2^x	3	3	3	2^x	2^x	2^x	3	3	2^x	2^x	2^x	3	3	3
11	3^x	3^x	4	4^x	4^x	4^x	4^x	4^x	2^x	3	3	3	3^x	4	4	4	2^x	2^x	2^x	2^x	2^x	2^x	2^x	2^x	3	3	2^x	3	3	3	3	3
12	4^x	4^x	4^x	4	3^x	3^x	3^x	3^x	4	4	4	4	3^x	3^x	3^x	3^x	2^x	2^x	2^x	2	2	2^x	2^x	2^x	2^x	2^x	2^x	2	2	1^x	1^x	1^x
13	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	4	3^x	3^x	3	3	3	3	3	3	3	3	1^x	1^x	1^x	2	2	2	2	2
14	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	4	3^x	4	4	4	3^x	3^x	3^x	3	3	3	2^x	2^x	2^x	2^x	2^x	2	2	2	2	1^x	1^x	1^x	1^x
15	3^x	3^x	3^x	3	3	3	3	3	3^x	3^x	3^x	3	3^x	3^x	3^x	3^x	2^x	2	2	2	2	2	2	2	1^x	1^x	1^x	2	2	2	2	2
16	3^x	3^x	3	3	3^x	3^x	3^x	4	3	3	3	3	3	3	3	2^x	1^x	1^x	1^x	1^x	1^x	2	2	2	2	2	1^x	1^x	1^x	1^x	1^x	1^x
17	4	4	4	4	3^x	3^x	3^x	3^x	2^x	2^x	2^x	2^x	2^x	2^x	3	3	2	2	2	2^x	2^x	2	2^x	2^x	1^x	1	1	1	1	1	1	1
18	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3	3^x	3^x	3^x	3^x	3^x	3^x	3^x	2^x	2	2^x	2	2	2	2	2	1	1	1	1	1	1	1	1
19	3^x	3^x	3	3	3	3	3	3^x	3^x	3^x	3^x	3	3	3	3	3	2	2	2^x	2^x	2^x	2^x	2^x	3	1	1	1^x	1^x	1^x	1^x	1^x	2
20	3^x	3^x	3^x	4	4	4	4	4	3	2^x	2^x	2^x	2^x	2	2	2	3	3	2^x	3	2^x	2^x	2^x	2^x	2	2^x	3	3	3^x	4	4	4
21	4	4	4	3^x	3^x	3^x	3^x	3	2	2	2	2	2	1^x	1	1	2^x	2	2	1^x	1^x	1	1	1	4	4	4	4	4	3^x	3	3
22	3	3	3	2^x	2^x	2^x	2	2	1	1	1	1	1	1	1	1	1	1^x	1^x	2	2	2	2^x	2^x	3	3	2^x	3	3	3^x	4	4
23	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	3	3^x	4	4^x	5	5	5	5	4	4	4	4	3^x	3	3	2^x
24	2	2	2	1^x	1^x	1^x	1^x	1^x	1	1^x	1^x	2	2	2^x	2^x	2^x	5	4^x	4^x	4^x	3^x	3^x	3^x	3^x	3	3	3	3	3	2^x	2^x	2^x
25	1^x	1^x	1	1^x	1^x	1^x	1^x	1^x	2^x	2^x	2^x	2^x	2	2	1^x	1^x	3^x	3^x	4	4	3^x	4	4	4	2^x	2^x	2^x	3	3	3	3	3^x
26	1^x	1^x	1^x	2	2	2	2	2	2	2	1^x	2	2	2	2	2	4	3^x	3^x	3^x	3^x	3	3	3	3^x	3^x	3	3	2^x	2^x	2	2
27	2	2	2	2	1^x	1^x	1^x	1^x	2	1^x	1^x	1^x	1^x	2^x	3^x	4	3	3	3	3	3	3	3	3^x	1^x	1^x	1^x	1^x	1^x	1^x	2	1^x
28	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x	4^x	4^x	4^x	5	5^x	5^x	5^x	5	3^x	3^x	3^x	3^x	3^x	3^x	3^x	3	1^x	1^x	1^x	1	1^x	1	1	1
29	1^x	1^x	1^x	1^x	1^x	1^x	1^x	1^x	5	5	5	5	4^x	4^x	4	4	3	2^x	2^x	2^x	2^x	2^x	2	2	1	1	1	1	1	0^x	0^x	0^x
30	1^x	1^x	1^x	1^x	1	1	1	1	4	3^x	3^x	3^x	3^x	3^x	3^x	3^x	2	2	2	2	1^x	1^x	1^x	1^x	0^x	0^x	0^x	0^x	0^x	0^x	0^x	0^x
31									3^x	3^x	3^x	3^x	3^x	3	3	3									0^x	0^x	0^x	0^x	0^x	0^x	1	1

2, March 3, July 11, October 2, October 3, October 28, and October 30. There were no completely quiet days but April 22, June 2, June 10, December 30, and December 31 were nearly quiet. Average minor activity was therefore well maintained during the year. It should be noted that the average relative sunspot-number for 1942 was 29.5.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C., January 30, 1943

LETTERS TO EDITOR

(See also page 17)

PROVISIONAL SUNSPOT-NUMBERS FOR OCTOBER TO DECEMBER, 1942 AND JANUARY, 1943

(Dependent alone on observation at Zürich Observatory)

Day	October	November	December	January
1	14	54	61	8
2	17	61[ab]	57	8
3	8	49	46*	8
4	0	40	35	8*
5	0	28	..	0*
6	0	36*	*E*15[cd]	15*[d]
7	18	31	31	10*
8	17	30*	31	14
9	27	*M*22[c]	26	12
10	*W*32[cd]	25	31[a]	17*
11	29	22[a]	29	14*
12	32	21	25	..[a]
13	9*	26*	20[a]*	12
14	9	28*	25	9
15	11[a]	23*	25	0
16	12	8	15	0
17	10	0	..	11
18	9*	0	8	*E*19[c]
19	17*	0	7	26
20	19	8*	0?	21
21	..	*E*33*[cd]	7	25[d]
22	25*	31	*M*18*[c]	25
23	17*	48[d]	27	15
24	16	39[a]	..	*M*25[c]
25	8	37	..	27
26	*E*13[c]	41*	..	10
27	31[dd]	52*	12*	8
28	39[a]	36*[b]	11	..
29	37	*M*63[ac]*	11[a]	7
30	51	73[d]*	11	0
31	44		11	8
Means......	19.0	32.2	22.9	12.5
No. days....	30	30	26	29

Mean for quarter, October to December, 1942, 24.8 (86 days)
Mean for year 1942,...................... 30.2 (349 days)

*Observed at Locarno.
[a]Passage of an average-sized group through the central meridian.
[b]Passage of a large group or spot through the central meridian.
[c]New formation of a group developing into a middle-sized or large center of activity: *E*, on the eastern part of the Sun's disk; *W*, on the western part; *M*, in the central-circle zone.
[d]Entrance of a large or average-sized center of activity on the east limb.

EIDGEN. STERNWARTE,
Zürich, Switzerland

W. BRUNNER

MAGNETIC ACTIVITY AT DOMBÅS BASED ON ABSOLUTE STORMINESS FOR THE HORIZONTAL COMPONENT

By K. F. Wasserfall

Introduction—Absolute storminess, AS, means the diurnal sum of positive and negative storminess, and is one of the best expressions for magnetic activity. Since 1916 daily values for AS, for D, H, and V, have been published in our year-books, but so far no attempt has been made to make further use of these valuable data, except that AS for D has been regularly used as the basis for our contribution to the international character-number, C.

For various reasons it has been considered desirable to devise a new international measure for magnetic activity in addition to the character-number, C. There is no doubt that AS would be a good basis for this new international measure except that few observatories compute data for AS. For this reason the Assembly at Washington in September 1939 decided to base the international cooperation, not on AS, but on the so-called three-hour-range index K. As the work required for deriving the K-index is much less than that connected with working out data for AS, this scheme for international cooperation seems to have been generally accepted, and—judging from results already published—there is every reason to believe that the K-index more or less covers what is required for the new measure for magnetic activity.

In spite of the fact that Dombås participates in the international cooperation connected with the K-index, a statistical investigation, based on AS, might still be of interest, and the present paper gives the results for an index for magnetic activity based on AS for H for Dombås for the 11-year period 1923-33.

Method—As data for AS, as well as those for the three-hour-range R, are functions of the geographical position of the station in question, they should be so reduced that they would be directly comparable to corresponding data for other observatories. The most practical procedure seems, therefore, to point in the direction of working out the factor of relation between AS and R for the three-hour range.

An inspection of our data for R for the three years 1939-41 shows that April 1939 furnishes convenient data for our purpose. These are plotted in Figure 1. The data for AS have been taken from our year-book [see 1 of "References" at end of paper], and corresponding data for R are taken from the unpublished tables used for computing data for K. According to instructions, data for K are not exclusively derived from the three-hour range for H, but from such data for one of the three elements, D, H, or V, which show the largest range within the three-hour interval in question. As it is rare for Dombås that the V-curve shows a larger range than the H-curve, it is practically only H and D that count under comparatively quiet magnetic conditions.

Our tables for AS_H have been compared therefore with the corresponding tables for AS_D, and AS_H replaced with AS_D when this latter element shows the larger range. For our station, Dombås, a rough inspection shows that AS_D is larger than AS_H from 0 to 40 per cent of the time. The values, AS'_H, so obtained and R for April 1939 are plotted in Figure 1. Regarding points for higher values of AS'_H and R, the highest point during April, 1939, depends on the two figures 4964 and 465, respectively; to get some additional points of high value,

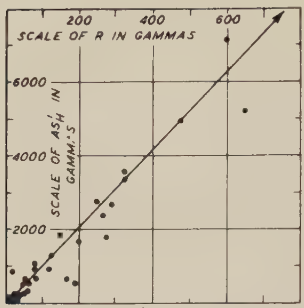


FIG. 1—GRAPH OF AS'_H AND THREE-HOUR RANGES R AT DOMBÅS, APRIL, 1939

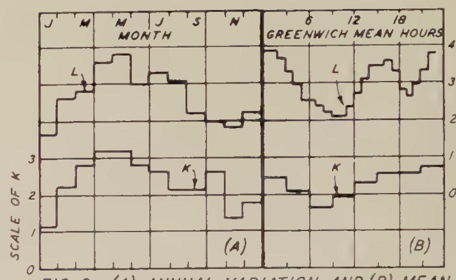
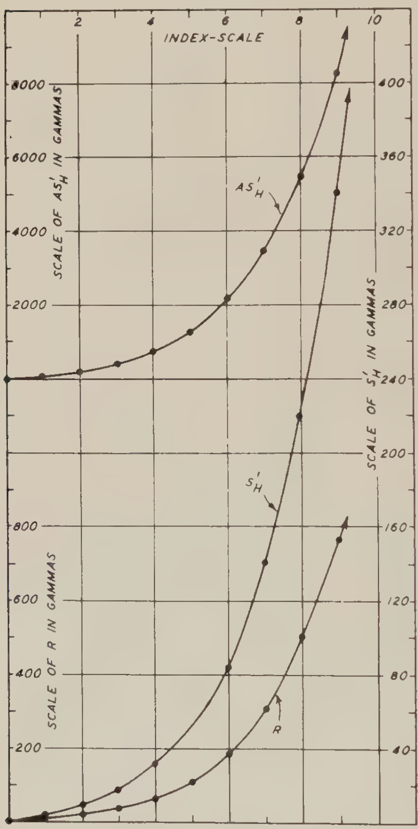


FIG. 3—(A) ANNUAL VARIATION AND (B) MEAN DIURNAL VARIATION OF INDICES K AND L AT DOMBÅS FOR 1939



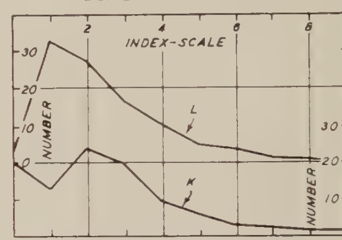


FIG. 4—FREQUENCY-DISTRIBUTION OF INDICES L AND K, DOMBÅS, 1939

FIG. 5—PERCENTAGE-FREQUENCY OF INDICES L AND K, DOMBÅS, 1939 (NUMBER OF VERTICAL LINES INDICATES INDEX AND LENGTH OF LINES INDICATES PERCENTAGE, BROKEN LINES REPRESENTING INDEX 0)

FIG. 2—RELATION OF ABSOLUTE STORMINESS AS'_H, HOURLY STORMINESS S'_H, AND THREE-HOUR RANGE R TO INDEX L, DOMBÅS, 1939

the data for April are supplemented with the data given in Table 1. The line through the points (Fig. 1), shows that $AS'_H = 10.8 \times R$.

TABLE 1—*Supplementary high values of AS'_H and R, Dombås, 1939*

Date	AS'_H	R	Date	AS'_H	R
Aug. 22	7093	688	Aug. 12	2658	279
May 1	3333	310	Aug. 16	2425	255

With the establishment of this relation between AS'_H and R, we have the required factor for reducing AS'_H. The values of the proposed new index, designated as L, depending on AS'_H, for Dombås are given in Table 2. That Table also shows L for values of hourly storminess, $S'_H = (AS'_H/24)$—added because this quantity is used for examination of the diurnal variation. Figure 2 shows values of S'_H, AS'_H, and R corresponding to various indices L for April, 1939.

TABLE 2—*Relations between index L and S'_H, AS'_H, and three-hour-range R at Dombås, 1939*

Index L	0	1	2	3	4	5	6	7	8	9
S'_H	0	4	8	17	31	51	82	141	221	340
R	0	8	15	30	60	105	180	300	500	750
AS'_H	0	90	205	400	740	1280	2150	3460	5410	8155

Comparison between results for K and L for 1939—In Table 3 we give the results for L for every day in 1939, and in Table 4 we have made a comparison between monthly mean data for K and L for the same

TABLE 3—*Index L based on AS'_H for Dombås, 1939*

Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	1.2	2.7	3.8	4.4	6.9	3.9	2.6	1.6	1.4	2.6	1.6	2.3
2	1.5	4.0	3.0	3.3	6.5	3.6	2.7	1.1	2.0	1.9	1.7	1.7
3	1.4	3.0	3.4	3.2	4.2	2.4	5.5	1.0	3.1	2.9	2.0	2.1
4	1.0	1.6	4.8	3.6	2.1	3.6	5.6	1.4	2.0	3.8	1.3	4.2
5	1.4	1.6	2.6	2.3	3.5	2.8	7.1	0.9	1.8	3.3	1.1	3.6
6	2.5	5.1	2.3	1.0	6.3	1.9	5.4	1.4	2.0	4.8	1.4	4.1
7	2.1	3.9	1.7	1.4	6.3	1.7	2.0	1.1	1.5	4.1	1.4	4.6
8	2.0	2.3	2.2	1.8	5.3	1.7	2.8	1.3	1.5	2.7	0.6	4.0
9	2.6	2.4	2.3	2.3	4.1	1.3	1.5	1.5	2.8	3.7	1.3	3.0
10	1.8	2.6	1.2	3.7	2.7	1.5	1.9	3.5	3.6	1.5	1.2	2.1
11	1.7	1.7	2.5	3.3	1.3	1.6	2.5	2.5	1.9	2.1	1.8	1.6
12	1.4	1.5	2.4	3.1	1.2	1.4	3.5	6.5	1.7	0.7	2.7	1.9
13	1.0	1.6	1.6	1.7	1.8	3.9	2.6	5.7	2.0	6.4	4.1	1.9
14	2.3	1.2	1.2	1.8	1.9	6.1	4.7	5.9	3.1	5.9	4.0	0.8
15	1.4	1.0	1.7	1.5	2.4	3.8	3.2	6.1	1.9	6.0	2.2	1.9
16	1.3	2.2	2.8	1.7	3.4	5.1	3.6	6.3	2.6	4.7	1.3	3.0
17	2.5	2.5	2.3	7.8	3.3	3.3	3.5	4.6	5.6	3.9	1.6	1.4
18	2.3	2.2	1.0	5.7	3.6	4.0	2.2	2.1	3.1	4.6	1.4	1.3
19	0.9	2.7	0.9	5.5	3.4	4.2	2.6	3.0	5.9	4.3	1.6	0.8
20	1.7	1.8	1.2	5.0	4.2	3.8	5.3	2.0	4.9	2.7	2.0	2.2
21	2.1	0.8	2.6	4.6	4.7	4.1	4.4	2.0	2.9	2.3	1.0	3.4
22	2.3	1.0	3.5	4.5	4.9	2.8	3.9	8.7	1.8	2.4	1.3	3.2
23	2.1	2.3	3.5	7.1	4.7	3.2	2.7	8.2	1.9	2.9	2.1	1.3
24	1.4	5.6	1.4	5.7	4.8	2.6	2.5	3.5	2.4	2.2	2.7	2.1
25	1.0	6.6	1.4	6.5	4.9	1.6	2.6	2.9	3.6	0.9	3.8	1.3
26	1.0	3.5	3.0	3.3	4.8	2.0	4.0	1.8	3.9	2.0	2.5	1.4
27	1.9	1.5	4.4	4.0	3.5	2.9	3.3	2.2	1.3	1.2	1.8	2.2
28	2.9	2.2	6.9	3.7	4.1	3.2	2.5	1.3	1.1	1.5	1.8	1.4
29	2.0		6.3	2.6	4.3	2.7	2.0	1.8	0.6	2.0	1.7	1.6
30	0.9		4.8	2.5	1.7	3.0	1.7	1.9	2.7	2.2	1.6	0.9
31	1.5		4.1		2.1		1.2	1.0		1.4		1.9
Mean	1.7	2.6	2.8	3.6	3.8	3.0	3.3	3.1	2.2	3.0	1.9	2.2

TABLE 4—*Mean indices L and K by months, Dombås, 1939*

Index	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
K	1.2	2.2	2.8	3.2	3.2	2.8	2.6	2.1	2.1	2.6	1.4	1.9
L	1.5	2.8	3.2	4.2	4.1	3.3	3.6	4.0	2.8	3.4	1.8	2.0

year. An inspection of the results for L shows that these figures are somewhat larger than the corresponding ones for K. The yearly means are 3.1 and 2.3, respectively. This may be partly attributable to the fact that the figures, depending on R (the three-hour range), embrace eight values per day while those depending on AS'_H have only one value per day, and that the R-data are compiled for index-values 1, 2, . . . 9, while the AS'_H-data are compiled for index-values 0.1, 0.2, . . . 8.9, 9.0. How much this may influence the results is difficult to say, but principally the disagreement depends on the factor itself. A small correction in the curvature of the graphs in Figure 2 would be sufficient to remove the disagreement. However this may be, we shall not make any change because it does not matter greatly if the results for the two indices disagree a little.

TABLE 5—*Hourly indices L and three-hour indices L and K, Dombås, 1939*

Hour	L	L	K	Hour	L	L	K
1	3.9			13	2.8		
2	3.9	3.8	2.5	14	3.1	3.1	2.4
3	3.7			15	3.5		
4	3.4			16	3.5		
5	3.2	3.0	2.1	17	3.6	3.5	2.6
6	2.6			18	3.3		
7	2.6			19	2.8		
8	2.4	2.4	1.6	20	2.7	2.8	2.6
9	2.2			21	3.0		
10	2.1			22	3.4		
11	2.1	2.2	1.9	23	3.8	3.7	2.7
12	2.3			24	3.8		
Mean	....	....	....	....	3.1	3.1	2.3

In Figures 3-A and 3-B we give the curves for the annual and diurnal variation for 1939, respectively. The curves for the annual variation agree fairly well—the points for maximum and minimum occur for both curves about May and November, respectively, and the amplitude is more or less of the same size. In regard to the diurnal variation, we see that many of the details are lost in the K-curve. The L-curve has a principal maximum between 10^h and 11^h in agreement with the K-curve. The secondary maximum of the L-curve, however, at about 20^h, is completely absent from the K-curve, though examination shows that the corresponding K-curve for 1940 has a slight indication of said minimum. The principal maximum in the L-curve, about midnight,

is also apparent in the K-curve, while the secondary maximum of the L-curve at about 16^h does not appear in the K-curve.

A frequency-table for index L for 1939 is given in Table 6. In

TABLE 6—*Frequency for index L for values of L from 0 to 9 in steps of 0.1, Dombås, 1939*

L	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Sum
0.0	0	0	0	0	0	0	2	1	3	6	12
1.0	11	4	9	13	18	12	13	15	12	13	120
2.0	15	11	11	12	7	10	12	11	5	6	100
3.0	7	4	5	7	4	9	7	4	5	7	59
4.0	6	7	3	2	3	1	4	4	5	3	38
5.0	1	2	0	2	1	2	3	3	0	3	17
6.0	1	2	0	4	1	3	1	0	0	2	14
7.0	0	2	0	0	0	0	0	0	1	0	3
8.0	0	0	1	0	0	0	0	1	0	0	2
9.0	0	..	..	..	..	..	..	..	..	..	0
Sum	41	32	29	40	34	37	42	39	31	40	365

TABLE 7—*Percentage-frequencies of L- and K-indices, Dombås, 1939*

Index-number	Index		Index-number	Index	
	L	K		L	K
0	3	20	5	5	6
1	33	13	6	4	3
2	27	24	7	1	2
3	16	20	8	1	1
4	10	10	9	0	1

Table 7 we give data for frequency in percentages; the frequency-figures in Table 7 depend on the sums in the last vertical column of

TABLE 8—*Index L, based on AS'_H, as mean monthly data for each year of 11-year interval 1923-33*

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	R
1923	1.1	1.5	1.6	1.4	1.6	1.8	1.4	1.6	1.5	1.7	1.2	1.1	1.46	14
1924	1.4	1.3	1.6	1.3	1.3	1.8	1.6	1.4	1.7	1.3	1.4	1.1	1.43	6
1925	1.3	1.2	1.4	1.6	1.8	2.5	1.8	2.2	2.4	2.5	1.7	1.8	1.85	17
1926	2.5	2.5	3.0	2.8	2.7	2.3	2.2	2.1	2.8	2.9	1.5	1.6	2.41	44
1927	2.2	2.2	2.8	2.7	2.5	2.2	2.2	2.7	2.6	2.7	1.8	2.0	2.40	64
1928	1.6	1.9	2.0	2.2	3.0	2.7	3.0	2.5	2.7	2.9	2.4	1.8	2.39	69
1929	1.8	2.6	2.8	1.9	2.1	2.3	2.7	2.3	2.6	2.5	2.3	2.3	2.35	78
1930	2.2	2.6	2.7	3.6	3.5	3.3	3.0	3.0	3.0	2.8	2.1	1.9	1.81	65
1931	1.8	1.9	1.9	1.6	1.9	2.0	2.0	2.2	2.4	2.7	2.2	2.0	2.05	36
1932	1.9	2.1	2.7	2.8	2.7	1.8	1.7	2.1	2.2	2.0	1.6	1.7	2.11	21
1933	1.8	1.9	2.0	2.2	2.3	2.0	1.8	2.0	2.4	1.3	1.8	1.6	1.92	11
Mean	1.8	2.0	2.2	2.2	2.3	2.2	2.1	2.2	2.4	2.3	1.8	1.7	2.51	39

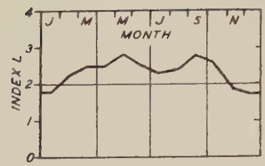


FIG. 6—MEAN MONTHLY VALUES OF INDEX L, DOMBÅS, 1923-33

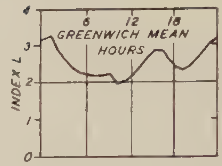


FIG. 8—AVERAGE DIURNAL VARIATION, INDEX L, DOMBÅS, 1923-33

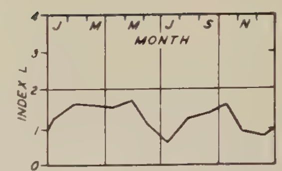


FIG. 9—MEAN ANNUAL VARIATION OF AMPLITUDE OF DIURNAL VARIATION OF INDEX L, DOMBÅS, 1923-33

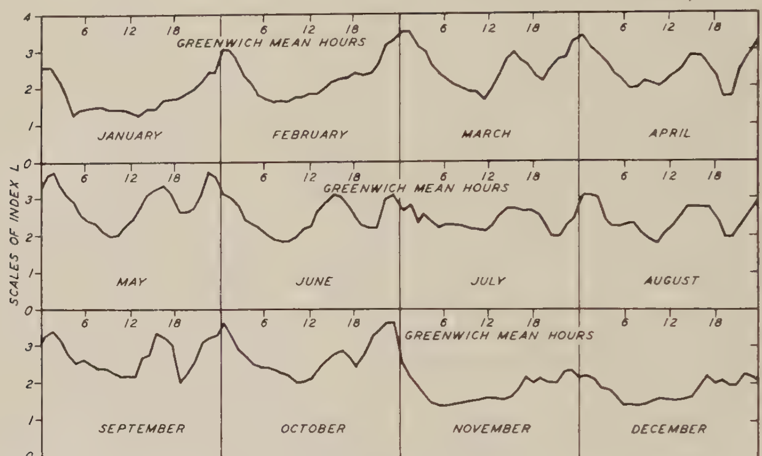


FIG. 7—11-YEAR MONTHLY MEANS DIURNAL VARIATION, INDEX L, DOMBÅS, 1923-33

Table 6. Data for frequency of *K* are added in Table 7. In Figure 4 we give the frequency-distribution for the different values of the indices. A comparison of the two results indicates that the most noticeable difference occurs in the distribution of the indices 0 and 1. In the case of *K* the frequency-figures are calculated for eight intervals per day, while in the case of *L* only one frequency-figure per day is included in the calculation of the mean figures for the year. This is the probable explanation of the fact that only three cases are entered for the index 0 for *L*, while in the case of *K* we have the high number of 20 cases.

Finally we give in Figure 5 a graph for frequency of *L*, plotted with the aid of the figures of Table 7.

Abstract of results for index L for the 11-year interval 1923-33—As it would require too much space to publish the results in detail, we shall limit ourselves to giving only an abstract of the results actually worked. In Table 8 we give monthly mean data for index *L* for every year during the 11-year interval 1923-33 [2]. Mean figures for the average annual variation will be found in the last horizontal row below and these values have been plotted in Figure 6, where we see that a principal and a secondary maximum occur in May and September with corresponding minimum points in December and August, respectively. The average

11-year variation appears from the figures tabulated under the heading "Mean" in the last column but one to the right, the sunspot-numbers being added in the last column to the right.

In Table 9 we give data for diurnal variation of index L for every year of the 11-year interval 1923-33. Average 11-year means will be

TABLE 9—*Diurnal variation for index L as annual means for the 11-year interval 1923-33*

Hours	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	Mean
1	1.8	1.6	2.6	3.9	3.2	3.1	3.5	4.4	2.7	3.0	2.7	2.9
2	1.9	1.7	2.5	3.8	3.0	3.3	3.4	4.3	2.5	3.0	2.5	2.9
3	1.8	1.4	2.4	3.4	2.8	3.1	3.0	3.9	2.3	2.6	2.4	2.6
4	1.6	1.2	2.3	2.9	2.7	2.6	2.9	3.6	2.2	2.4	2.1	2.4
5	1.3	1.1	2.0	2.8	2.5	2.4	2.6	3.3	2.1	2.3	1.9	2.2
6	1.2	1.0	2.0	2.6	2.4	2.2	2.4	2.8	2.0	2.0	1.8	2.0
7	1.1	1.1	1.9	2.5	2.5	2.4	2.3	2.6	1.8	2.0	1.6	2.0
8	1.2	1.2	1.8	2.3	2.3	2.3	2.2	2.5	1.8	1.9	1.6	1.9
9	1.3	1.3	1.8	2.2	2.3	2.3	2.0	2.5	1.9	1.8	1.7	1.9
10	1.5	1.5	1.7	2.0	2.2	2.3	2.0	2.4	1.9	1.7	1.6	1.9
11	1.5	1.6	1.7	2.0	2.2	2.2	2.0	2.2	1.8	1.7	1.4	1.8
12	1.6	1.5	1.6	2.2	2.4	2.4	2.1	2.2	1.7	1.8	1.5	1.9
13	1.6	1.4	1.7	2.5	2.5	2.5	2.4	2.5	1.8	1.8	1.7	2.0
14	1.7	1.5	1.9	2.6	2.8	2.8	2.7	3.0	2.0	2.1	2.1	2.3
15	1.7	1.6	2.0	3.0	3.0	3.0	2.9	2.5	2.3	2.3	2.2	2.4
16	1.7	1.7	2.3	3.2	3.2	3.1	3.1	2.4	2.3	2.4	2.4	2.5
17	1.7	1.7	2.2	3.4	3.1	3.0	3.3	2.4	2.2	2.5	2.3	2.5
18	1.8	1.6	2.1	3.2	2.8	3.0	3.2	2.3	2.2	2.4	2.2	2.4
19	1.8	1.6	2.0	2.7	2.6	2.4	2.7	3.1	2.3	2.2	2.0	2.3
20	1.8	1.5	2.0	2.6	2.4	2.3	2.4	2.6	2.3	1.8	1.8	2.1
21	1.9	1.5	2.1	2.9	2.5	2.4	2.8	2.8	2.2	2.3	1.9	2.3
22	2.0	1.6	2.4	3.2	2.7	2.5	3.1	3.4	2.4	2.5	2.1	2.5
23	2.0	1.7	2.6	3.7	3.0	2.9	3.3	3.9	2.5	2.8	2.5	2.8
24	2.1	1.6	2.6	3.7	3.2	3.2	3.4	4.1	2.6	2.7	2.5	2.9

found in the last column to the right. In Table 10 we give a second expression for the diurnal variation of index L. The figures of this Table represent 11-year means. The mean data in the last column to the right are somewhat different from those in Table 9. The reason is, of course, that a different combination is used to extract the mean value—in Table 9 the mean has been taken as 11-year averages for each hour while in Table 10 they are derived from 11-year means for every month during the epoch 1923-33. The figures of Table 9 have been used for plotting Figure 7, where the 11-year means for diurnal variation for index L, for every month, are drawn.

From the data for means, in the horizontal row below in Table 10, we see that the annual variation is nicely developed. In Figure 8 we give a graph for the average for the 12 months of the year. Finally we have tabulated in the last three horizontal rows below in Table 10 the maximum, minimum, and amplitude of the monthly data for the diurnal variation plotted in Figure 7. A graph plotted with said data for the amplitude of the diurnal variation is given in Figure 9. In this connection it may be remarked that the average points for the monthly

mean diurnal maximum and minimum figures of Table 10 occur at $00^h\ 55^m$ and $12^h\ 50^m$, respectively.

TABLE 10—*Mean diurnal variation of index L, 11-year means per month, Dombås, 1923-33*

Hour	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1	2.6	3.1	3.4	3.3	3.7	3.2	2.7	3.1	3.3	3.6	2.5	2.2	3.2
2	2.6	3.0	3.4	3.0	3.8	3.2	2.6	3.1	3.5	3.4	2.3	2.1	3.3
3	2.2	2.9	3.1	2.9	3.3	2.9	2.4	3.1	3.2	3.0	1.8	1.8	3.0
4	1.8	2.4	3.0	2.7	3.2	2.6	2.7	2.5	2.7	2.7	1.7	1.6	2.7
5	1.3	2.1	2.6	2.4	3.0	2.5	2.5	2.3	2.6	2.5	1.6	1.5	2.4
6	1.3	1.8	2.4	2.2	2.6	2.3	2.3	2.3	2.7	2.4	1.5	1.4	2.3
7	1.4	1.7	2.2	1.8	2.5	2.2	2.3	2.3	2.6	2.4	1.6	1.4	2.2
8	1.4	1.6	2.0	2.0	2.4	2.2	2.3	2.2	2.4	2.3	1.7	1.5	2.2
9	1.5	1.7	1.9	2.1	2.2	2.1	2.3	2.1	2.4	2.2	1.6	1.5	2.1
10	1.5	1.7	1.9	2.0	2.0	2.0	2.3	1.9	2.3	2.1	1.6	1.6	2.2
11	1.5	1.7	1.8	2.0	2.0	2.1	2.2	1.8	2.3	2.0	1.5	1.6	2.0
12	1.5	1.8	1.7	2.2	2.3	2.2	2.2	2.1	2.2	2.0	1.4	1.6	2.1
13	1.4	1.8	2.1	2.4	2.6	2.3	2.3	2.3	2.4	2.1	1.5	1.6	2.3
14	1.3	1.9	2.5	2.6	2.9	2.6	2.6	2.6	2.8	2.5	1.6	1.6	2.5
15	1.4	2.1	2.7	2.8	3.2	2.9	2.8	2.8	3.0	2.6	1.8	1.7	2.7
16	1.5	2.2	2.9	2.9	3.3	3.2	2.8	2.8	3.0	2.8	2.0	1.9	2.6
17	1.6	2.3	2.8	2.8	3.4	3.1	2.7	2.8	3.1	2.9	2.1	2.3	2.9
18	1.7	2.3	2.6	2.6	3.2	2.9	2.7	2.8	2.9	2.7	2.2	2.0	2.8
19	1.9	2.4	2.3	2.3	2.7	2.6	2.6	2.4	2.0	2.4	2.2	2.1	2.5
20	1.9	2.2	2.2	1.7	2.5	2.4	2.3	2.0	2.3	2.8	2.2	2.0	2.4
21	2.1	2.4	2.6	1.9	2.6	2.2	2.0	2.0	2.7	3.3	2.3	1.9	2.5
22	2.3	2.7	2.7	2.5	3.1	2.2	2.0	2.3	3.1	3.4	2.3	2.3	2.6
23	2.5	3.1	2.9	2.8	3.8	3.0	2.4	2.6	3.2	3.7	2.3	2.2	3.1
24	2.5	3.3	3.1	3.3	3.7	3.1	2.5	2.9	3.2	3.7	2.3	2.1	3.2
Mean	1.8	2.3	2.5	2.5	2.9	2.6	2.4	2.4	2.8	2.7	1.9	1.8	2.6
Max.	2.6	3.3	3.4	3.3	3.8	3.2	2.7	3.1	3.5	3.7	2.5	2.3	3.4
Min.	1.3	1.6	1.7	1.7	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.4	1.9
Ampl.	1.3	1.7	1.7	1.6	1.8	1.2	0.7	1.3	1.5	1.7	1.0	0.9	1.5

The annual mean frequency-distribution of the figures for index L on scale of 0, 1, . . . 9 is given in Tables 11 and 12. In the latter

TABLE 11—*Annual mean frequency for index L, Dombås, 1923-33*

Year	0	1	2	3	4	5	6	7	8	9
1923	120	165	53	17	6	2	2	0	0	0
1924	112	171	65	9	6	2	1	0	0	0
1925	74	153	88	30	12	6	2	0	0	0
1926	30	131	112	48	17	17	6	4	0	0
1927	24	115	148	47	18	7	8	1	0	0
1928	15	127	150	45	15	8	4	1	1	0
1929	13	165	99	50	19	12	5	1	1	0
1930	15	93	117	67	43	24	6	0	0	0
1931	22	168	121	44	8	1	1	0	0	0
1932	32	157	111	50	12	2	0	2	0	0
1933	33	170	117	39	4	1	0	1	0	0
Mean	45	147	107	41	15	7	3	1	0	0

Table such data are entered as percentages, and these quantities are plotted graphically in Figure 10 as "*frequency-trees*" for each year during the interval 1923-33.

TABLE 12—*Annual mean frequency in percentage for index L, Dombås, 1923-33*

Year	0	1	2	3	4	5	6	7	8	9
1923	33	45	14	5	2	1	0	0	0	0
1924	31	46	18	3	2	0	0	0	0	0
1925	20	42	24	8	3	2	1	0	0	0
1926	8	36	31	13	5	4	2	1	0	0
1927	7	31	41	13	5	2	1	0	0	0
1928	4	36	41	12	4	2	1	0	0	0
1929	4	45	28	14	5	2	1	1	0	0
1930	4	25	32	18	12	7	2	0	0	0
1931	6	46	33	12	2	1	0	0	0	0
1932	9	43	30	14	3	1	0	0	0	0
1933	9	47	32	11	1	0	0	0	0	0
Mean	12	40	29	17	4	2	1	0	0	0

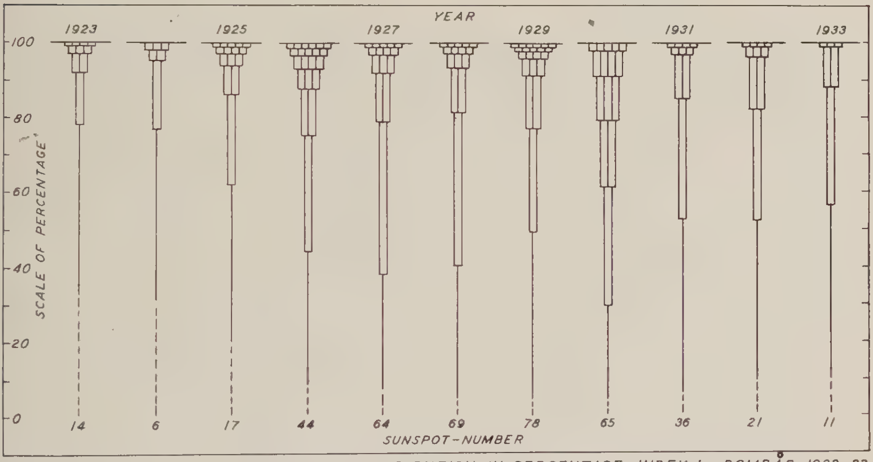
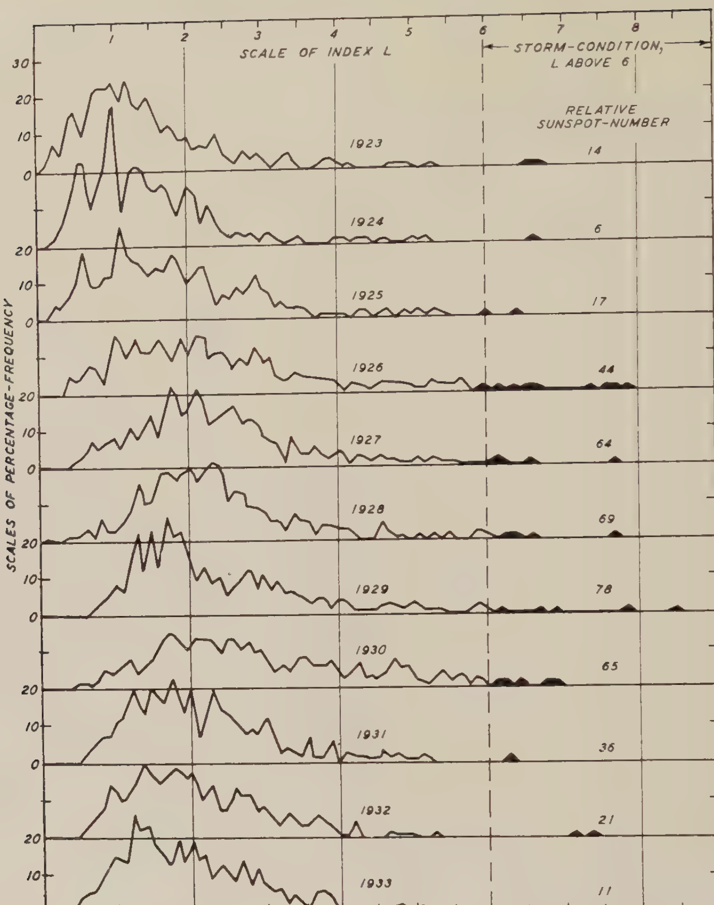


FIG. 10—YEARLY MEAN FREQUENCY-DISTRIBUTION IN PERCENTAGE, INDEX L, DOMBÅS, 1923-33 (SEE EXPLANATORY NOTE IN FIGURE 5)

General remarks—Besides the graph for frequency-distribution given in Figure 10, we may give a second graph for these data, this time using the L-scale 0.0, 0.1 . . . 8.9, 9.0. Some details are thus exhibited which seem of importance for our investigation. According to Bartels [3], we may make the following grouping for the L-scale employed: Quiet conditions, $L=0$ or 1; moderately disturbed, $L=2$, 3, 4, or 5; actual storminess, $L=6$, 7, 8, or 9. In Figure 11 are shown all the scattered cases with values of L above 6 indicated by black areas. To the left of the Figure we have included the sunspot-figures for the epoch in question. We see that the relation between these sunspot-numbers and the black areas is fairly good, but here, as in the case of nearly all such data for magnetic activity, the chief disagreement in



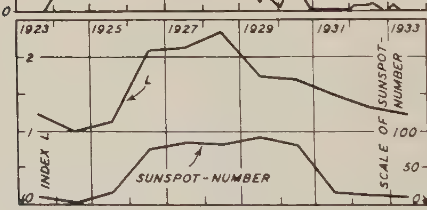


FIG. 11—ANNUAL FREQUENCY-DISTRIBUTION, INDEX L, DOMBÅS, 1923-33

FIG. 12—COMPARISON INDEX L AND RELATIVE SUNSPOT-NUMBERS, DOMBÅS, 1923-33

the curves is that the 11-year period of magnetic activity exhibits a varying double wave, due to the much greater influence of the eight-year periodicity, than in the case of the sunspot-data. The only data actually giving a curve which is nearly parallel with the 11-year period of the sunspots are found in Hansteen's classical illustration of this phenomenon, in which for magnetic activity he uses the diurnal difference between observations of declination at 09^h and 14^h.

From the data for frequency of index L of Table 12, we obtain another selection of figures, namely, those given in Table 13. Here are tabulated

the maximum number of cases for each year and the corresponding L-indices. In Figure 12 we have used the figures under index L for comparison with the sunspot-numbers plotted below. The curve for

TABLE 13—*Maximum annual percentage-frequencies and number of cases and corresponding values of L, Dombås, 1923-33*

Year	Maximum frequency			
	L	Per cent	L	No. cases
1923	1.2	25	1	165
1924	1.0	40	1	171
1925	1.1	25	1	153
1926	2.1	17	1	131
1927	2.1	22	2	148
1928	2.3	21	2	150
1929	1.7	26	1	165
1930	1.7	15	2	117
1931	1.5	23	1	168
1932	1.3	19	1	157
1933	1.2	26	1	170

these index-figures gives a much higher degree of parallelism with the sunspots than does a curve plotted with the case-numbers tabulated in the second and fourth columns of Table 13.

References

[1] B. Trumpy and K. F. Wasserfall, Results from the magnetic station at Dombås, 1939, Bergen, Pub. Norsk Inst. Kosm. Fys., No. **20** (1941).

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[3] J. Bartels, N. H. Heck, and H. F. Johnston, The three-hour-range index measuring geomagnetic activity, Terr. Mag., **44**, 411-454 (1939).

DET MAGNETISKE BYRÅ,
Bergen, Norway, July 15, 1942

REVIEWS AND ABSTRACTS

(See also page 44)

J. A. FLEMING (Editor). *American Geophysical Union. Transactions of 1942.* Washington, D. C., National Research Council, 740 pp. with illus. (August and November 1942.) 25 cm.

Since the meeting of the American Geophysical Union in the spring of 1941, the relentless extension of World War II has engulfed most of the nations that were then neutral rendering difficult the maintenance of international collaboration in geophysics and the prosecution of studies based on data from all parts of the Globe practically impossible. Under these circumstances, it is gratifying to note that studies in all branches of Earth physics have been carried on in the Americas with undiminished vigor as is evident from the large amount of research-work reported at the 1942 session of the Union and embodied in the present volume of its *Transactions*.

The *Transactions* of 1942 consist of two parts: Part I contains the reports and papers presented at the joint regional meetings of the Section of Hydrology (A) with the American

Association of the Advancement of Science at Dallas, Texas, December 31, 1941, and (*B*) with the Western Interstate Snow-Survey Conference, Pasadena, California, January 16-17, 1942. Part II is devoted to the reports and papers presented at the general assemblies of the Union and meetings of the Sections of Geodesy, Seismology, Meteorology, Terrestrial Magnetism and Electricity, Oceanography, Volcanology, Hydrology, and Tectonophysics at the twenty-third annual meeting, Washington, D. C., April 3 and 4, 1942. It also contains the minutes of the business session of the General Assembly and of the Sections as well as the reports of the General Secretary, the Secretaries of the Sections, and the Chairmen of the various Committees.

At the evening General Assembly held April 3, 1942, in the Hall of Government of the George Washington University, the fourth award of the William Bowie Medal, endowed and established in 1939, for distinguished and outstanding contribution to the advancement of cooperative researches in geophysics, was made to Captain Nicholas Hunter Heck "author, magnetician, oceanographer, and seismologist," who had been chief of the Division of Geomagnetism and Seismology of the United States Coast and Geodetic Survey for about 20 years. The presentation of the medal was followed by the address of the President, Dr. W. C. Lowdermilk, on the subject of "Prophetic science" reproduced in Part II of the *Transactions*. The lecture of the evening was given by Bradford Washburn on "Recent explorations in the mountains and glaciers of Alaska." It was illustrated with colored motion-pictures of the beauty-spots of the regions traversed and gave an account of the author's exploration of the Mount Hayes Region of Alaska, under the sponsorship of the New England Museum of Natural History of Boston, Mass. Only a brief abstract of this lecture is given in the *Transactions*.

The papers and reports presented at the session of the Section of Terrestrial Magnetism and Electricity are of particular interest to readers of the JOURNAL. They are printed in full or in abstract in Part II of the *Transactions*. Their titles are as follows: Earth's magnetic field and actual heights in the ionosphere, by H. W. Wells; Geomagnetic survey of a portion of southeastern New York, by R. A. Geyer; Geomagnetic bays, their frequency and current-systems, by H. B. Silsbee and E. H. Vestine: The annual variation of geomagnetism, by E. H. Vestine; Recent alterations in geomagnetic secular variation in eastern North America, by H. H. Howe; Methods used in the production of the 1940 isogonic chart of the United States, by D. G. Knapp; Atmospheric-electric observations at the Needham Laboratory for Cosmic Terrestrial Research, by H. T. Stetson; On the anomalous diurnal variation of air-conductivity and potential-gradient at the Huancayo Magnetic Observatory, by M. W. Jones and P. G. Ledig; Atmospheric-electric results from simultaneous observations over the ocean and at Watheroo, Western Australia, by G. R. Wait; Overcoming the humidity-problem at a tropical magnetic observatory, by J. Hershberger; Magnetic work of the United States Coast and Geodetic Survey from April 1941 through March 1942, by O. W. Swainson; Researches in terrestrial magnetism and electricity at Department of Terrestrial Magnetism, Carnegie Institution of Washington, for the year April 1941 to March 1942, by J. A. Fleming.

The effective manner of presenting the material which has characterized the previous volumes of the *Transactions* is conspicuous in these of 1942. The offset process of reproduction, adopted several years ago, has been employed but the master-copy was prepared with a proportionate-spacing typewriter which imparts to the text an appearance resembling that of a printed page, economizes space, and facilitates perusal. On the whole the amount of material contained in the *Transactions* of 1942 is about equal to that of those of 1941, indicating that there has been no decrease in the amount of geophysical research accomplished in America during the period in question but rather more, if investigations carried out in connection with the war which cannot be made public are taken into consideration.

H. D. HARRADON

VECTOR-DIAGRAMS OF ANNUAL VARIATION OF MAGNETIC ACTIVITY IN DECLINATION AND HORIZONTAL INTENSITY, OSLO, 1843-1886

By K. F. Wasserfall

The reduction of horizontal-intensity determinations made by Christopher Hansteen and his successors at the Oslo Observatory (latitude 59° 54′.77 north, longitude 10° 43′.4 east) during 1840 to 1930 was published in 1941 in two papers [see 1 and 2 of "References" at end of paper]. The first paper [1] contains complete daily data for horizontal intensity, H, at 09^h and 14^h with a short explanatory text, while the second paper [2] gives detailed data of the complicated reductions of the absolute determinations of declination, D, and includes summarized tabulations, graphs, and discussion.

About two years ago the author began compilations of the daily data for D for the same interval, 1843 to 1930 [3]. These for 09^h and 14^h during 1843-1886, that is for four of the eight 11-year epochs, are now completed. It seemed worth while to compile vector-diagrams of the annual variations in D and H and of $\triangle H = (\triangle H_{14} - \triangle H_{09})$ and $\triangle D = (\triangle D_{14} - \triangle D_{09})$ given in Table 1.

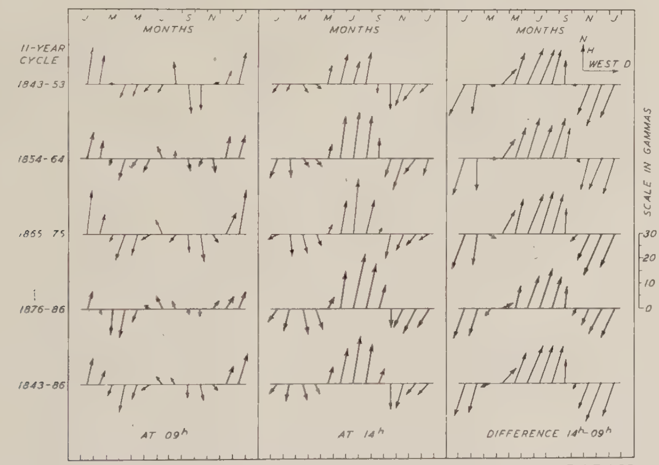

FIG. 1—SUCCESSIVE MEAN HOURLY VECTORS BY MONTHS IN RESULTANT HORIZONTAL INTENSITY AT 09^h AND 14^h AND THEIR DIFFERENCES, FOR 11-YEAR INTERVALS AND FOR WHOLE INTERVAL, DOMBÅS, 1843-86

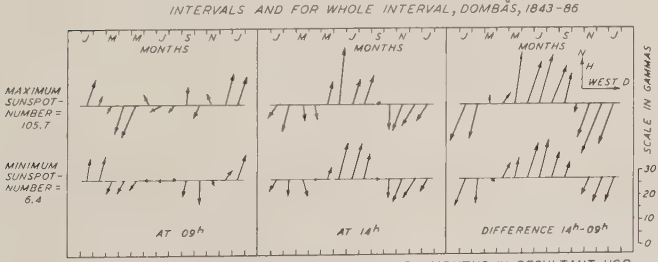

FIG. 2—SUCCESSIVE MEAN HOURLY VECTORS BY MONTHS IN RESULTANT HORIZONTAL INTENSITY AT 09^h AND 14^h AND THEIR DIFFERENCES, FOR SUNSPOT MAXIMUM AND MINIMUM, DOMBÅS, 1843-86

TABLE 1—*Mean annual variations of horizontal intensity and of declination at* 09^h *and* 14^h (H_{09}, H_{14}, D_{09} *and of* $\triangle H=(\triangle H_{14}-\triangle H_{09})$ *and* $\triangle D=(\triangle D_{14}-\triangle D_{09})$, *Oslo, 1843-1886*

Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
							H at 09^h (H_{09})					
1843-53	15	12	0	−7	−5	−3	−5	−9	−13	−12	1	6
1854-64	10	7	−4	−11	−5	−7	4	2	−6	−4	−7	8
1865-75	18	8	−4	−11	−7	−2	6	−3	−9	−13	−4	8
1876-86	7	−2	−11	−13	−6	1	6	3	−2	−3	2	5
Mean	12	6	−5	−10	−6	−3	3	−3	−7	−8	−2	7
							H at 14^h (H_{14})					
1843-53	−3	−4	−3	−1	8	12	9	13	−3	−11	−9	7
1854-64	−8	−9	−4	−4	6	17	19	17	8	−7	−12	−6
1865-75	−1	−9	−9	−6	4	14	23	15	2	−12	−8	−5
1876-86	−6	−10	−11	−9	5	15	23	18	8	−7	−6	−8
Mean	−5	−8	−7	−5	6	14	19	16	4	−9	−9	−7
							$\triangle H=(\triangle H_{14}-\triangle H_{09})$					
1843-53	−14	−13	−1	7	13	15	14	15	9	−1	−13	−17
1854-64	−16	−14	0	8	13	16	13	16	13	−2	−14	−14
1865-75	−15	−14	−2	8	14	15	17	16	10	−3	−11	−17
1876-86	−12	−11	−3	2	9	13	16	13	9	−3	−7	−12
Mean	−14	−13	−1	6	12	15	15	15	10	−2	−11	−15
							D at 09^h (D_{09})					
1843-53	2	1	−1	−2	−2	−3	−2	−1	1	0	2	3
1854-64	2	1	−1	−2	−2	−2	−2	0	1	−1	1	2
1865-75	2	1	−2	−3	−2	−3	−2	−2	0	1	2	3
1876-86	2	1	−1	−2	−2	−2	−2	−1	0	0	1	2
Mean	2	1	−1	−2	−2	−3	−2	−1	0	1	2	3
							D at 14^h (D_{14})					
1843-53	−3	−2	2	2	1	2	2	2	0	0	−3	−4
1854-64	−3	0	3	3	1	2	2	2	0	−1	−3	−4
1865-75	−3	0	2	3	1	2	2	2	1	−1	−3	−3
1876-86	−3	−2	2	2	1	2	3	3	2	0	−3	−4
Mean	−3	−1	2	3	1	2	2	2	1	0	−3	−4
							$\triangle D=(\triangle D_{14}-\triangle D_{09})$					
1843-53	−6	−2	3	6	4	6	5	3	0	0	−4	−6
1854-64	−5	0	4	6	4	5	5	4	1	1	−3	−6
1865-75	−6	−2	2	5	3	5	4	3	0	−2	−5	−7
1876-86	−5	−3	2	4	2	4	4	3	0	−1	−3	−7
Mean	−5	−2	3	5	3	5	4	3	0	−1	−4	−6

Table 2 gives the mean annual variations for maximum and minimum years of sunspots for H_{09}, H_{14}, and $\triangle H$ and D_{09}, D_{14}, and $\triangle D$ at the Oslo Observatory during 1843 to 1886. The mean relative sunspot-number for maximum years is 105.7 and for minimum years is 6.4 for the four 11-year epochs.

Graphs of the data given in Tables 1 and 2 are given in Figures 1 and 2.

TABLE 2—*Mean annual variations of maximum and minimum for components H_{09}, H_{14}, and $\triangle H$ and D_{09}, D_{14}, and $\triangle D$, Oslo, 1843-86*

Element	Character	Month												
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
		γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ
		H_{09}, H_{14}, and $\triangle H=(\triangle H_{14}-\triangle H_{09})$												
H_{09}	Max.	11	2	−2	−12	−6	5	−1	−2	−9	−6	4	12	11
	Min.	10	10	−4	−5	−3	0	0	1	−7	−11	−2	3	10
H_{14}	Max.	−5	−13	−7	−6	10	23	20	12	1	−10	−11	−8	−5
	Min.	−4	−6	−7	0	5	15	15	11	0	−8	−8	−7	−4
$\triangle H$	Max.	−17	−16	0	6	19	18	21	15	12	−3	−14	−21	−17
	Min.	−12	−12	−2	6	8	14	15	10	7	0	−8	−13	−12
		D_{09}, D_{14}, and $\triangle D=(\triangle D_{14}-\triangle D_{09})$												
D_{09}	Max.	3	1	−1	−2	−2	−3	−3	−1	0	−1	−2	2	3
	Min.	2	2	−1	−2	−2	−2	−1	0	0	0	1	2	2
D_{14}	Max.	−3	−1	1	2	1	2	3	2	1	0	−3	−5	−3
	Min.	−3	0	2	3	1	3	3	2	1	0	−3	−4	−3
$\triangle D$	Max.	−7	−2	3	4	2	4	5	4	1	0	−3	−4	−3
	Min.	−5	−2	2	3	4	5	5	3	0	−1	−4	−6	−5

References

[1] K. F. Wasserfall, The horizontal component of magnetic intensity at Oslo Observatory, 1843-1930 (daily values for 09 and 14 o'clock), Geofys. Pub., Oslo, **13**, No. 2 (1941).

[2] K. F. Wasserfall, Magnetic horizontal intensity at Oslo, 1843-1930, Terr. Mag., **46**, 173-218 (1941).

[3] K. F. Wasserfall, Declination at Oslo, 1843-1930 (in preparation).

DET MAGNETISKE BYRÅ,
Bergen, Norway, April 10, 1942

REVIEWS AND ABSTRACTS

(See also page 39)

A. Ogg: *Magnetic observations at the secular-variation field-stations in the Union of South Africa and Southwest Africa, and a comparison with corresponding values at the Magnetic Observatory, Cape Town.* Trans. R. Soc. S. Africa, **29**, 261-278 (1942).

The important project of determining secular variation of the Earth's magnetic field by means of observations made at regular intervals at selected stations well-distributed over the Earth's surface, has received consideration at meetings of the International Union of Geodesy and Geophysics and a special Committee promoting this work has been functioning since 1930. The outbreak of the war and the involvement of many countries in hostilities have interfered with the execution of the program. In South Africa, however, not only has the secular-variation work been undertaken but it has also been carried out on a more extensive scale than that recommended by the above-mentioned Committee.

The field-work in South Africa was greatly facilitated by the use of instruments associated with the name of the late Dr. D. la Cour, namely, the quartz horizontal-intensity magnetometer (QHM No. 29) and the magnetic balance (BM No. 10) to which the author ascribes the success of the survey-work. An Askania declinometer was also used.

The stations were chosen with great care and marked with cylindrical non-magnetic concrete piers to carry the instruments and assure exact reoccupations. Sketches and photographs showing environment of stations and azimuth-marks are preserved at the Hermanus Observatory to facilitate future work.

The daily changes as measured at the various stations showed very good agreement with the Observatory's magnetograms. This is exhibited by four figures showing typical graphs of the diurnal variation for quiet, slightly disturbed, and considerably disturbed days. It was found in this survey that the difference between the mean values at the Observatory and a station may be taken to be the same on a disturbed as on a calm day (except on a very disturbed day at a distant station). At nine stations where full-period observations were taken, the difference of the mean values on disturbed and those on quiet days varied only as follows: D, $0'.7$; H, $+1\gamma$; Z, $+1\gamma$.

On October 1, 1940, magnetic observations were made at Van Rhynsdorp to determine a possible effect of the total solar eclipse on that day. Observations of D, H, and Z were taken on the day of the eclipse, on the day before, and on the day after. As the day of the eclipse happened to be a disturbed one, there was no opportunity for detecting a possible eclipse-effect.

Tables of the magnetic values obtained at the secular-variation field-stations and the corresponding values at the magnetic Observatory, Cape Town, accompany the paper.

H. D. Harradon

J. W. Broxon: *Relation of the cosmic radiation to geomagnetic and heliophysical activities.* Phys. Rev., **62**, 508-522 (1942).

Relations between 28-day fluctuations of intensity of the cosmic radiation and both terrestrial-magnetic activity and sunspot-areas were investigated. Definite pulses, both in the magnetic character and in sunspot-areas, were found to be associated with the primary pulses in the cosmic radiation at Boulder, obtained by Chree's "superposed-epoch" method. They were in general phase opposition to the cosmic pulses, but the tip of the magnetic-character pulse preceded the tip of the opposite cosmic-ray pulse by one day; the lead was three or four days in the case of the opposed sunspot-pulses. Similar relations were not found among secondary pulses, although a 34-day periodicity in sunspot-area pulses referred to days selected on the basis of cosmic-ray intensity was displayed. Direct application of Chree's method to the magnetic character and sunspot-areas, individually, indicated a 27-day periodicity in the former and a 34-day periodicity in the latter. A second method of investigation, used by Graziadei, Kohlhörster, and others, was also employed. This yielded results in some respects contradictory to the first. In particular, it indicated 27-day fluctuations in sunspot areas in phase with the cosmic-ray fluctuations and out of phase with changes in magnetic character. However, it also indicated the 34-day periodicity in sunspot areas for the period of the investigation was more pronounced than the 27-day periodicity. Among other possibilities, the possible effects of sunspots through the agency of their magnetic fields were considered.

(Author's abstract)

THE MUTUAL CONSISTENCY OF SUCCESSIVE MONTHLY MEANS OF DECLINATION, HUANCAYO MAGNETIC OBSERVATORY

By W. E. Scott

In reducing the declination-records for 1942 of the Huancayo Magnetic Observatory of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, the changes in base-line values appeared to be somewhat larger than usual. Thus the adopted base-line during January 1 to 10, 1942, was 6° 33′.0 east and the observed values of declination required a regular progression of changes to May 15, when for the next succeeding 20 days the adopted base-line was 6° 33′.9. Hence the excellence of adopted base-lines was tested by plotting the monthly means. Vestine, in his article "Reduction of magnetic observations to epoch" [Terr. Mag., **47**, 97-113 (1942)], has pointed out that "the geomagnetic east component of the departures is small in all latitudes."

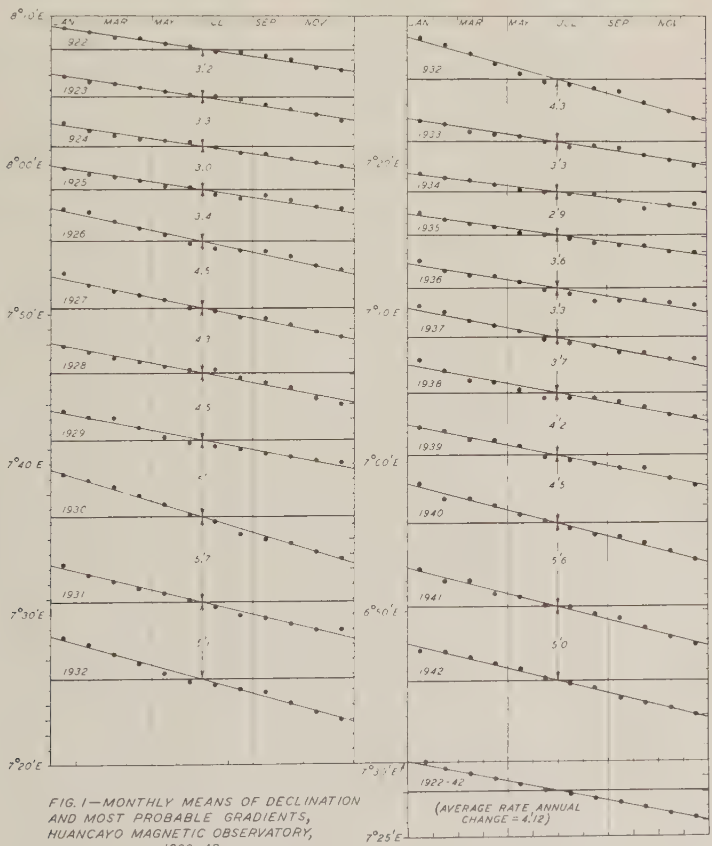

FIG. 1—MONTHLY MEANS OF DECLINATION AND MOST PROBABLE GRADIENTS, HUANCAYO MAGNETIC OBSERVATORY, 1922-42

In Table 1 are given the monthly mean values of declination, based on records of all days during 1922-42, which period covers nearly two sunspot-cycles. These values were plotted, as in Figure 1, and the most probable gradient determined for each year by means of least squares. In 1922, the initial year of the Observatory's operation, declination for January and February are lacking and so the most probable values were deduced by the principle of least squares, as likewise for November and December, 1942, for which months the records had not yet come to hand. A composite graph for the epoch 1922-42 of monthly mean values showed little or no variation in declination with season. It is gratifying to note how closely the plotted means follow the annual trend—evidence of precision in the determination of declination at Huancayo. The method is a simple and reliable way of testing the accuracy of observatory-results and, perhaps, may even be used to disclose inaccurate instrumental constants. For example, if one were to examine the consistency of results as found, observatory for observatory, and then convert any inconsistencies back to declination again, it would appear that one might be able to estimate the possible error in absolute magnetic standards used relative to the consistent

TABLE 1—*Mean monthly declination (all days) for Huancayo Magnetic Observatory*

Year	Month												Mean
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
	′	′	′	′	′	′	′	′	′	′	′	′	′
	8° east plus												
1922	09.19*	08.94*	08.54	08.51	08.14	07.99	07.60	07.58	07.33	07.05	06.51	06.33	(07.81)
1923	05.90	05.57	05.44	05.21	04.91	04.72	04.63	04.39	04.02	03.71	03.34	02.97	04.57
	7° east plus												
1924	62.86	62.29	61.93	61.73	61.64	61.57	61.17	60.76	60.75	60.37	60.08	59.89	61.25
1925	59.78	59.33	59.18	58.95	58.58	58.51	58.01	57.76	57.94	57.66	57.17	57.07	58.33
1926	57.08	56.85	56.24	55.80	55.35	54.74	54.41	54.30	54.25	53.87	53.24	52.97	54.92
1927	52.77	51.93	51.59	51.31	50.98	50.39	50.21	49.81	49.75	49.31	48.80	48.49	50.44
1928	47.94	47.51	47.08	46.87	46.59	46.30	46.32	45.77	45.42	45.10	44.36	43.97	46.10
1929	43.59	43.19	43.09	42.46	41.84	41.46	41.21	40.97	40.71	40.53	40.27	40.10	41.62
1930	39.35	38.91	38.51	37.91	37.35	36.66	36.26	35.37	34.97	34.74	34.17	33.70	36.49
1931	33.32	32.62	32.24	31.73	31.41	30.99	30.52	29.94	29.76	29.37	28.95	28.98	30.82
1932	28.48	28.04	27.40	26.73	26.08	25.55	25.34	25.04	24.84	24.10	23.45	23.01	25.67
1933	22.94	22.71	22.22	22.00	21.88	21.50	21.15	21.22	21.03	20.59	20.25	19.87	21.45
1934	19.37	19.08	18.91	18.62	18.24	18.11	17.94	17.94	17.48	16.97	17.17	17.29	18.09
1935	16.75	16.31	15.96	15.79	15.39	15.22	14.97	14.65	14.55	14.44	14.03	13.98	15.17
1936	13.49	12.88	12.54	12.44	12.03	11.53	11.25	10.77	10.75	10.81	10.62	10.45	11.63
1937	10.46	10.02	09.46	09.12	08.74	08.19	07.92	07.74	07.32	07.26	06.80	06.85	08.32
1938	06.84	06.11	05.46	05.33	04.79	04.29	04.24	04.24	04.00	03.64	03.08	02.91	04.58
	6° east plus												
1939	62.31	62.04	61.46	61.44	61.01	60.28	60.06	59.82	59.52	59.54	58.82	58.33	60.39
1940	58.60	57.56	57.52	57.05	56.42	56.00	55.48	55.12	54.92	54.50	53.96	53.39	55.88
1941	52.85	52.04	52.08	51.15	50.92	50.35	50.26	49.75	49.47	48.83	48.22	47.71	50.30
1942	47.40	47.30	46.91	46.47	46.13	45.54	45.10	44.87	44.15	43.78	43.44*	43.02*	(45.34)
Mean 7°+	30.06	29.58	29.23	28.89	28.50	28.09	27.81	27.51	27.28	26.96	26.51	26.25	28.06

*Most probable values deduced by principle of least squares from series of monthly means for respective year.

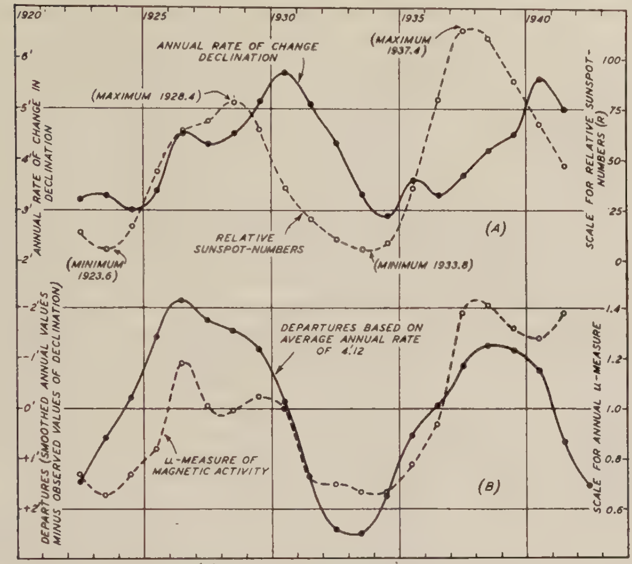

FIG. 2—COMPARISONS (A) ANNUAL RATE OF CHANGE IN DECLINATION AT HUANCAYO MAGNETIC OBSERVATORY WITH ANNUAL MEAN RELATIVE SUNSPOT-NUMBERS AND (B) DEPARTURES OF OBSERVED ANNUAL VALUES OF DECLINATION FROM SMOOTHED ANNUAL VALUES WITH ANNUAL MEAN VALUES OF u-MEASURE OF MAGNETIC ACTIVITY, 1922-42

observatories. In addition to its utility, the method reveals the rather interesting effect of the sunspot-cycle upon the annual change, the rate of annual change being accelerated during sunspot-maximum and retarded during sunspot-minimum.

In Figure 2-*A*, the annual rates of change in declination for Huancayo from 1922 to 1942 and annual mean relative sunspot-numbers are plotted. The indication is that a large part of the annual variation in magnetic activity is of external origin, closely associated with variations in solar activity. Attention is called to the close degree of equality, numerically, of the two maximum rates of change in declination ($-5'.7$ and $-5'.6$) and the two minimum rates ($-3'.0$ and $-2'.9$) for the respective parts of sunspot-cycles. As usual, the maximum positions of the two curves are displaced by about 2-1/2 years. This condition possibly can be attributed to the fact that maximum frequency of number of magnetic storms lags behind the maximum of sunspots, and hence the post-perturbation effects which contribute to the variation of a sunspot-cycle are greater several years after maximum of sunspots is obtained.

In Figure 2-*B* the annual departures of observed annual values of declination from smoothed annual values and the *u*-measure of magnetic activity are plotted. During the 21 years from 1922 to 1942, the total change in the mean annual declination at Huancayo was $-1° 22'.47$, or an average of $-4'.12$ each year. Using as base the mean value of declination during 1922-42, $7° 28'.06$, the value of $\pm 4'.12$ was successively applied for years prior to and following 1932, in order to obtain smoothed annual values. The differences (smoothed annual values minus observed) were plotted in Figure 2-*B*, together with the *u*-measure

(values for 1937-41 are provisional) of magnetic activity, and these two curves agree somewhat better in phase than those of Figure 2-*A*.

It is appropriate perhaps to mention here Wasserfall's interesting work [Terr. Mag., **46**, 173-221, 1941] in reducing the long series (1843-1940) of magnetic horizontal-intensity records left by Hansteen and successors for Oslo. He encountered some difficulty with the many abrupt changes in base-line values, and in this connection stated on page 217 that he had "made partial use of the supposed pronounced 11-year period as a hint to the correction for the base-line values during intervals where B_h (the base-line values) could be fixed with the aid of absolute observations."

It is realized, of course, that Huancayo Observatory is a special case only, since a linear relationship exists when its annual mean values of declination are plotted, whereas for some magnetic observatories the linear relationship does not hold over the period of observations. It is to be hoped that a generally applicable method can be devised for determining the annual rates of change during a sunspot-cycle. Perhaps Ad. Schmidt's method ["Ergebnisse der magnetischen Beobachtungen in Potsdam und Seddin in den Jahren 1900-1910," Abhandl. Kgl. Preuss. Meteorol. Inst., **5**, No. 3, Berlin, 1916], or some adaptation of it, may serve the purpose.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C., February 9, 1943

EFFECT OF SMOKE ON THE ATMOSPHERIC-ELECTRIC ELEMENTS AT THE WATHEROO MAGNETIC OBSERVATORY

By G. R. Wait

Abstract—Intense smoke at the Watheroo Magnetic Observatory effectively increases the total resistance of the vertical column of air over the station. This and other evidence indicate that the smoke extends to a height of about one km. The total resistance of the vertical column of air over the Observatory varies greatly through the day. Both the variation and the average value are increased by the presence of smoke. Factors other than the number of condensation-nuclei and radioactive matter in the atmosphere, it is believed, may be effective in producing a diurnal variation in this total resistance. The intensity of smoke at Watheroo appears to be independent of the direction and velocity of the wind. The rate of ionization (small-ion production) in the lower atmosphere over a station on land is found to vary considerably through the day, being greatest during the early morning hours and least during the evening. The cause for the variation appears to be a variation in the amount of radioactive matter in the air.

Considerable smoke is produced during the summer months in Western Australia through the burning of fields by farmers and of brush on the sand-plains by kangaroo-hunters. As a consequence, smoke is often observed at the Watheroo Magnetic Observatory during the summer. Days when smoke occurs are interspersed more or less irregularly among days when there is no smoke observable, such days being most common during the month of February. It was apparent from the beginning of the conductivity-registrations in 1922 that smoke had a pronounced depressing effect upon the conductivity. In the summer of 1924, after the potential-gradient registrations were started, the value of potential-gradient was found to be much greater when smoke was present. Steps were accordingly taken to secure a more quantitative measure of the effect of smoke on the various atmospheric-electric elements through simultaneous measurements of the number of condensation-nuclei, the potential-gradient, and the positive and negative conductivities [see 1 of "References" at end of paper]. Additional simultaneous observations of the nuclei and the atmospheric-electric elements were made during the summer of 1928 and the results were discussed by Builder [2]. Both sets of data show an approximate linear variation of the number of nuclei in the air with the potential-gradient as well as with the reciprocals of the conductivities. In a review of both sets of conductivity-data, Gish [3] points to the fact that these data are consistent with the recombination-law.

$$q=\alpha n^2+\beta nN \tag{1}$$

N and n refer to the nuclei and the small-ion content, respectively, of the air; q represents the rate of small-ion production; α is the recombination-coefficient of small ions; and β is the coefficient of combination between small ions and condensation-nuclei. It was pointed out that the value of q so obtained was surprisingly small. Both sets of data are consistent in showing a small value for both q and β. The values computed on the basis of equation (1), assuming 1.5 cm/sec/volt/cm as the mobility of the small ions and 1.6×10^{-6} as the value for α, are

$q=2.2\ I$ and $\beta=0.44\times10^{-6}$ from the data of 1924, and $q=1.2\ I$ and $\beta=0.88\times10^{-6}$ from the data of 1928.

Values of q as small as these can hardly be regarded as real and one may question whether (a) the number of small ions in the lower atmosphere can be fully accounted for on the basis of equation (1) or whether (b) equation (1) must be modified and to what extent. This matter has been touched upon by the writer [4] and was later examined in considerable detail by Nolan [5]. It deserves further consideration but is not treated in the present paper because the character of the atmospheric-electric data from Watheroo is such that information may more readily be obtained on other equally important questions.

The calculated value of the air-earth current for both 1924 and 1927 diminishes as the number of nuclei increases, thus indicating that the total resistance between the ground and the upper conducting layer is effectively increased by the nuclei. Simultaneous atmospheric-electric and condensation-nuclei data are very limited. Many more atmospheric-electric data from Watheroo without simultaneous condensation-nuclei data are now available for study. Some of these were utilized by Torreson and the writer [6] in a preliminary analysis of the effect of smoke on the atmospheric-electric elements at Watheroo. The results as a whole are in agreement with those obtained from other studies. One result of that study, namely, that the value of the air-earth current is essentially the same on smoky and non-smoky days, however, is not in agreement with those obtained from the simultaneous measurements of nuclei and atmospheric-electric elements. This was also not borne out in a study, later made by the writer [7], of simultaneous atmospheric-electric data over the oceans and at Watheroo. It seemed desirable, therefore, to continue the study of this question in order to determine the reason for the lack of agreement.

In the preliminary analysis, attention was given to the effect of smoke on the atmospheric-electric elements during the months of November, December, January, February, and March, 1924-34. It was assumed that the difference between all complete days and the selected days (selected on the basis of no smoke-effect and no storm-effect) would adequately represent days with pronounced smoke-effects. While this assumption seemed justified at the time, later study proved this not to be the case. Such differences also include days when storms occurred and also days having other undesirable characteristics.

The present study utilized data only during February, the month when the smoke occurs most frequently and is of greatest intensity. All days in February during the 11-year period 1924-34 were critically examined for smoke and other effects. The days were grouped under one of three headings: (1) Select, least-disturbed, fair-weather days when there was no evidence of smoke at the Observatory; (2) fair-weather days when the notes of the observers indicated presence of smoke or when definite evidence of smoke appeared to be unmistakable from the character of the atmospheric-electric records themselves (the latter chiefly during the night when the observers were not on duty); and (3) days regarded as doubtful as to the presence of smoke, as well as days when stormy weather or other pronounced disturbing influences were present. It was found necessary to reject the data for both 1924 and 1934, the former because the positive conductivity was not recorded

and the latter since only three smoky days were available for February.

The intensity of smoke at the Observatory is not uniform throughout the day, but is greatest during the night—a conclusion in agreement with the careful notes of the observers and with the results obtained from a comparison of the corresponding hourly values of the various atmospheric-electric elements on smoky and non-smoky days. Such a comparison may be made of the potential-gradient, sum of positive and negative conductivities, ratio of positive to negative conductivity, and of the computed air-earth current, by reference to Figure 1. It is apparent from these curves that the smoke causes an increase in the

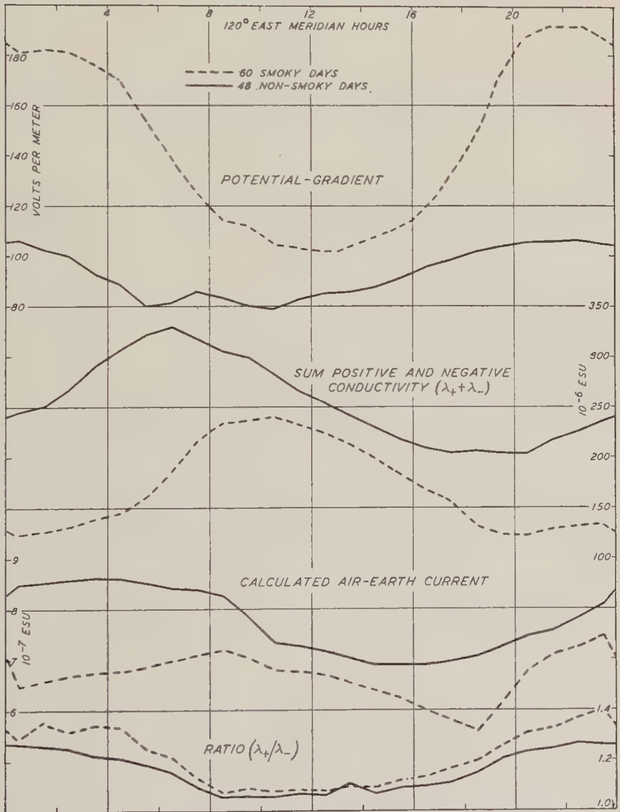

FIG. 1—DIURNAL VARIATION OF ATMOSPHERIC-ELECTRIC ELEMENTS AT WATHEROO FOR SMOKY AND NON-SMOKY DAYS DURING FEBRUARY, 1926-34

potential-gradient, a decrease in the sum of the conductivities, a relatively small change in the ratio of positive to negative conductivity, and a lowering of the air-earth current. It also is evident that the effect of the smoke is more pronounced during the night than during daylight. The relative effects of smoke from hour to hour can better be seen through the ratio of potential-gradient on smoky to that on non-smoky days

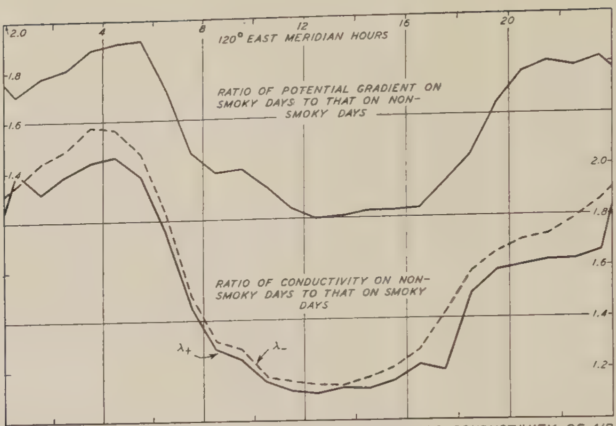

FIG. 2—EFFECT OF SMOKE ON POTENTIAL-GRADIENT AND CONDUCTIVITY OF AIR AT WATHEROO, FEBRUARY, 1926-34

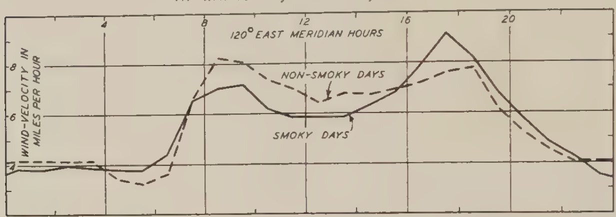

FIG. 3—DIURNAL VARIATION IN WIND-VELOCITY AT WATHEROO, FEBRUARY, 1930-34

and through the ratio of conductivity on non-smoky to that on smoky days. The diurnal variations in this ratio for potential-gradient, positive conductivity, and negative conductivity are shown in Figure 2. The greatest values of the ratio occur during the night and the smallest during daylight. The increase in the potential-gradient and the decrease in the two conductivities due to the smoke are around 50 to 100 per cent during the night while only from 20 to 40 per cent during daylight, thus clearly indicating that the smoke occurs almost exclusively at night.

The cause for the appearance of smoke almost exclusively at night at Watheroo is not at once apparent. One might consider the wind as an important factor. The velocity of the wind is generally low at night and then rises sharply at about the time when the smoke tends to disappear. Possibly the smoke accumulates in the lower air at the Observatory during the time of day when the wind-velocity is low only to be scattered and distributed to greater heights as the wind increases in velocity, thus diminishing the intensity of smoke near the ground. The smoky day would accordingly correspond to a day of low wind-velocity and the non-smoky day to one of higher wind-velocity. The apparent effects of the smoke on the air-earth current—the latter being smaller when smoke is present—seem inconsistent with such an explanation, because the average wind-velocity on smoky days is found to be not essentially different from that on non-smoky days, as may be seen from Figure 3 where the diurnal-variation curves for wind-velocity are plotted for smoky and non-smoky days during February 1930 to February 1934. Also utilizing wind-velocity data for the two hourly

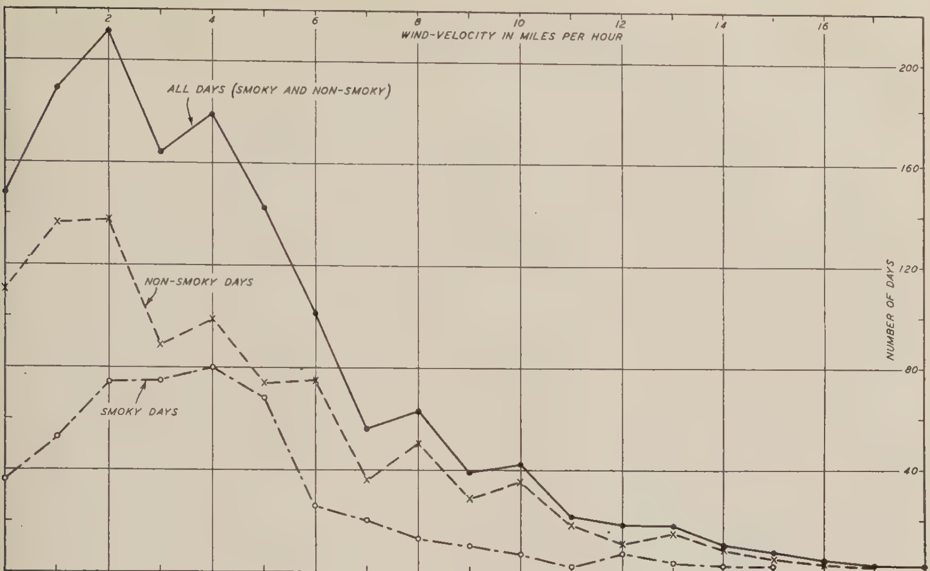

FIG. 4—MEAN FREQUENCY-CURVES FOR WIND-VELOCITY AT WATHEROO, INTERVALS 0^h-1^h AND 4^h-5^h, JANUARY TO MARCH, 1926-34

intervals 00^h-01^h and 04^h-05^h, when the smoke-intensity is generally greatest, it was found that the frequency-distributions of wind-velocity for smoky and for non-smoky days, shown in Figure 4, do not differ appreciably. To be consistent with the above suggested explanation of the variation of intensity of smoke from day to day, the smoky-day curve should be shifted towards the left with respect to that for the non-smoky days. Apparently such an explanation cannot be accepted.

In order to determine whether the tendency for wind to blow from the smoke-producing areas is greater during the night than during daylight, and on smoky rather than on non-smoky days, frequency-curves for wind-direction were drawn for every fourth hourly interval, 00^h-01^h, 04^h-05^h, 08^h-09^h, ... throughout the 24 hours for both smoky and non-smoky days during the month of February from 1924 to 1934, that is, the total number of days when the wind blew from a given direction was plotted against that particular direction. One set of curves of Figure 5 shows the directions for daylight hours of 8 to 17 while the other set is for the night hours of 20 to 5. There appears to be no tendency for a reversal in the direction of the

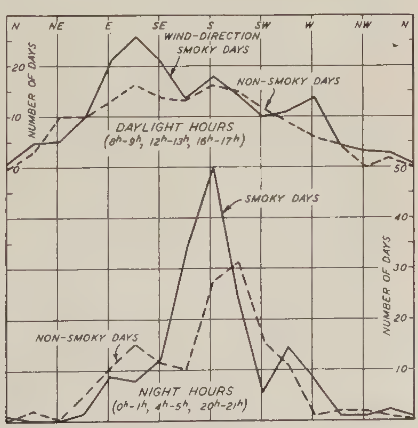

FIG. 5—WIND-DIRECTION AT WATHEROO, FEBRUARY, 1924-34

wind between smoky and non-smoky days nor between night and daylight. Only minor differences in the directions for smoky and non-smoky days are observable either at night or during daylight. The appearance of smoke at Watheroo seems, therefore, not to be associated with any particular direction of the wind. The average temperature for each hour of the day for smoky and non-smoky days was compared and always found to agree within a fraction of a degree. It is believed that the smoke at the Observatory, appearing as it does only occasionally and then mostly at night and since it appears not to be associated with velocity or direction of wind or with air-temperature, can be explained through the fact that fires are set only at such times.

Attention is directed to the method employed in the present study for computing values of the air-earth current from the values of potential-gradient and conductivity. The mean value of the air-earth current may be derived from the mean product of potential-gradient and conductivity or from the product of the mean potential-gradient and the corresponding mean conductivity. In a comparison of values for Fairbanks, computed by the two different methods, Sherman [8] found that the latter gave values in excess of those derived through the former method. He also showed from theoretical considerations that this will generally prove to be the case. The average excess is $-r\sigma_g\,\sigma_\lambda$, where σ_g and σ_λ are the computed standard deviations of the gradient and conductivity, respectively, and r is the correlation-coefficient between the gradient and conductivity, which generally will be negative in sign. In the case of the smoky and non-smoky days of the present study, the average differences by the two methods of computation were 0.9 and 0.3, respectively. The former represents about 14 per cent of the average smoky-day value of current while the latter is about four per cent of the average current for the non-smoky days. These results emphasize the importance for exercising caution in selecting the method to be followed in computing the average values of air-earth current. The values plotted in Figure 1 are the means of the individual products of gradient and conductivity.

It was pointed out above that the average value of the air-earth current on the 60 smoky days used in this study differed appreciably from that on the 48 non-smoky days. In a preliminary study, Torreson and the writer [6] concluded that "the calculated air-earth current is essentially the same for smoky and non-smoky days, indicating that the decrease in conductivity on smoky days is largely confined to a relatively thin layer of air near the ground in which there occurs a corresponding increase in potential-gradient." The results of this survey and of the preliminary study are not in accord in this respect. The principal reason for this is apparently the manner in which the so-called smoky days were selected in the preliminary study. It was explained that "after selecting the least-disturbed, fair-weather days for the months of November to March, of which there were 407 in the 11-year period, there remained 504 complete days which were almost without exception smoky days." The assumption that in the latter group the days were almost without exception smoky days now appears hardly justifiable. They were largely smoky days, but it appears obvious from tests using the data for the month of February from 1926 to 1934 that a number of other days were included sufficient to affect

the results. It must be concluded, therefore, that the presence of smoke at Watheroo tends to reduce the value of the air-earth current. This indicates that the smoke is distributed throughout a vertical thickness sufficient to affect appreciably the total resistance of the vertical air-column through which the air-earth current passes.

An estimate of this effective vertical thickness was made by the method previously outlined by the writer [7]. Adopting the same notations, according to the development given in the article just referred to, one can write $(i_O/i_W)=(1/R_O)\ (r'_W+h_W\rho_W)$ where the subscripts refer to simultaneous values over the ocean and at Watheroo, respectively. The air-earth current is represented by i, the resistance of the upper stratum of air by r', the resistivity and thickness of the lower stratum by ρ and h, respectively. According to the above equation, a plot of the ratio (i_O/i_W) against the resistivity ρ_W of the lower stratum of air at Watheroo should yield a straight line, provided R_O and r'_W are constant. There are good reasons for regarding both as approximately constant through the day, and a plot was accordingly constructed, one for non-smoky and another for smoky days at Watheroo. Unfortunately, values of i_O for all the Februaries of 1926 to 1934 are not available but only for 12 days during February, 1929. In view of the general uniform behavior of this element, as judged from a comparison of results from

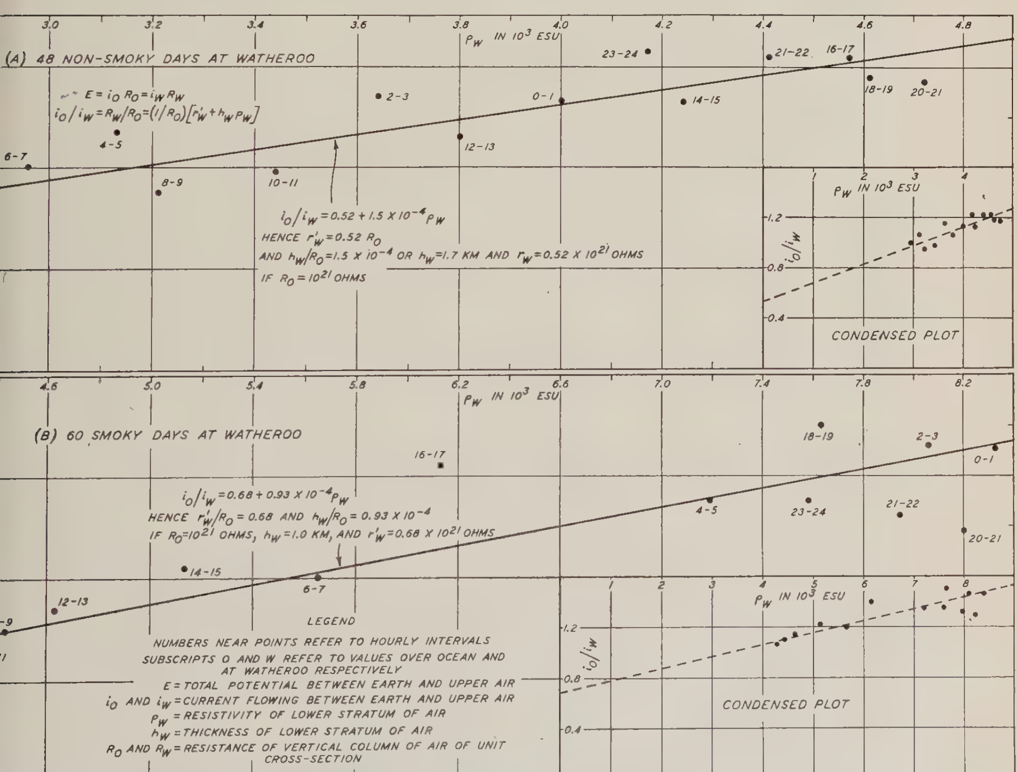

FIG. 6—PLOT FOR DETERMINING THICKNESS OF LOWER STRATUM OF AIR AT WATHEROO FOR 9-YEAR PERIOD, FEBRUARY, 1926-34

the various cruises of the *Carnegie*, no great error will be introduced through the use of such values of i_O with the corresponding hourly values of i_W for the entire period of 1924 to 1934. The resulting plots are given in Figure 6. In the case of the non-smoky days, the points scatter about the line whose equation is $(i_O/i_W)=0.52+1.5\times10^{-4}\ \rho_W$. Consequently $(1/R_O)\ (r'_W+h_W\ \rho_W)=0.52+1.5\times10^{-4}\ \rho_W$, that is, $r'_W=0.52\ R_O$, and $h_W=1.5\times10^{-4}\ R_O$. Assuming that $R_O=10^{21}$ ohms, then $r'_W=0.52\times10^{21}$ ohms and $h_W=1.7$ km. Following a similar procedure for smoky days, the points are found also to scatter about the line whose equation is $(i_O/i_W)=(1/R_O)\ (r'_W+h_W\ \rho_W)$ where the values of (r'_W/R_O) and (h_W/R_O) are 0.68 and 0.93×10^{-4}, respectively. Likewise if $R_O=10^{21}$ ohms, $r'_W=0.68\times10^{21}$ ohms and $h_W=1.0$ km. These values are in reasonably good agreement with those obtained from the simultaneous data of 1928-29, namely, r'_W and h_W being 0.49 R_O and $1.4\times10^{-4}\ R_O$ for the smoky days and 0.53 R_O and $1.4\times10^{-4}\ R_O$ for the non-smoky days. It is noted for the non-smoky-day plot of Figure 6 that the plotted points for the early morning hours lie above the curve as drawn; this same tendency was noted in the case of the simultaneous data of November-December, 1928, and January-February, 1929 [7], and the curve was so drawn as to indicate that this may represent an increase in effective height of the lower stratum of air. Another interpretation seems possible, however, as will be seen from Figure 7.

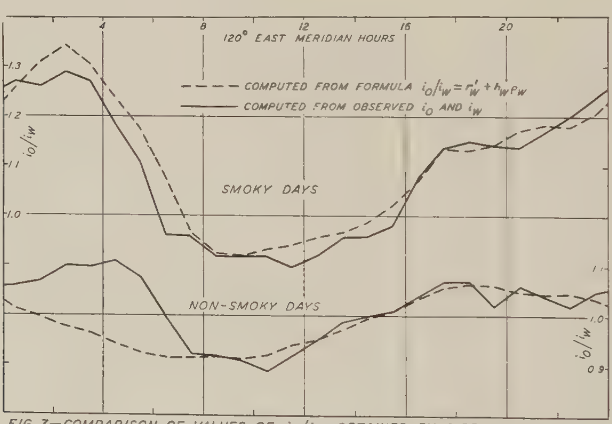

FIG. 7—COMPARISON OF VALUES OF i_O/i_W OBTAINED BY DIFFERENT METHODS USING SIMULTANEOUS OCEAN AND WATHEROO DATA, NOVEMBER AND DECEMBER, 1928, AND JANUARY AND FEBRUARY, 1929

The diurnal-variation curves of Figure 7 represent the ratio of (i_O/i_W) from observed simultaneous values of i_O and i_W for the period November-December, 1928, and January-February, 1929. The plotted crosses represent values of this ratio as computed from the equation $(i_O/i_W)=(1/R_O)\ (r'_W+h_W\ \rho_W)$ regarding R_O, r'_W, and h_W as constants having values as given in the previous paragraph; that is to say, a column of air having a height h_W and a resistivity ρ_W with the added resistance r'_W, would have a total resistance relative to R_O of the amount indicated by the crosses. It is at once apparent that if the entire air-

column had a resistivity (ρ_W) equal to that near the ground, the total resistance of the vertical air-column would be slightly greater than is found during the morning of the smoky days and considerably less than that found during the morning of the non-smoky days. In other words, it suggests that during the morning hours of the smoky days the smoke was somewhat more intense near the ground than it was some distance above the ground. At the same time, the smoke, or at least the condensation-nuclei content of the air, during the morning hours of the non-smoky days, according to this interpretation, was less near the ground than it was at a distance above the ground. This in turn suggests that the origin of the smoke in the case of the smoky days was not far removed from the Observatory, while on non-smoky days it was some distance away. The resistivity of the lower layer of air is generally presumed to be largely controlled by the rate of ionization and the condensation-nuclei content of the air as indicated by equation (1). It is important to point out in this connection that q, the rate of ionization, at Washington has been found to pass through a maximum during the early morning and there is good reason for believing that it will do so at Watheroo as well. This should be another important factor tending to cause the points represented by the crosses to fall below the curve during the early morning. That they do so only on the non-smoky days may only imply that on those occasions the value of q has increased relatively more than has N, while on smoky days the reverse may be true.

Wind may be very effective in altering the various atmospheric-electric elements at any station. The effect of wind at Watheroo is likely to be different on smoky days than on non-smoky days. It seemed possible that information concerning the way in which the various elements vary with wind-velocity might assist in a better understanding of the distribution of condensation-nuclei in the atmosphere during both smoky and non-smoky days. The values of the potential-gradient, positive conductivity, and negative conductivity were, therefore, averaged for the various wind-velocities, 0, 1, 2, . . . miles per hour for smoky and for non-smoky days. The values for only two hourly intervals (00^h-01^h, 04^h-05^h) were used in order to avoid the introduction of any effect due to a diurnal variation. All days in the three months, January, February, and March, 1926-34, were used in order to include a sufficient number of days to give reliable results. The resulting mean values of the potential-gradient and those for the sum of positive and negative conductivity are plotted against the corresponding wind-velocity in Figure 8 for non-smoky days (A) and for smoky days (B). The plotted values of air-earth current are from the product of the mean potential-gradient and the mean conductivity. The ratio of positive to negative conductivity was derived from the corresponding mean value of each element. The number of observations for the smoky days was considerably smaller than that for the non-smoky days, and the results must be considered less reliable. In the case of the conductivity during the smoky days, the points scatter greatly, thus introducing considerable uncertainty. There appears to be a tendency for the values of this element to increase with wind-velocity for velocities greater than four or five miles per hour and for the values of the air-earth current to remain more or less constant, thus resulting in a decrease in the potential-gradient towards higher wind-velocities. The ratio

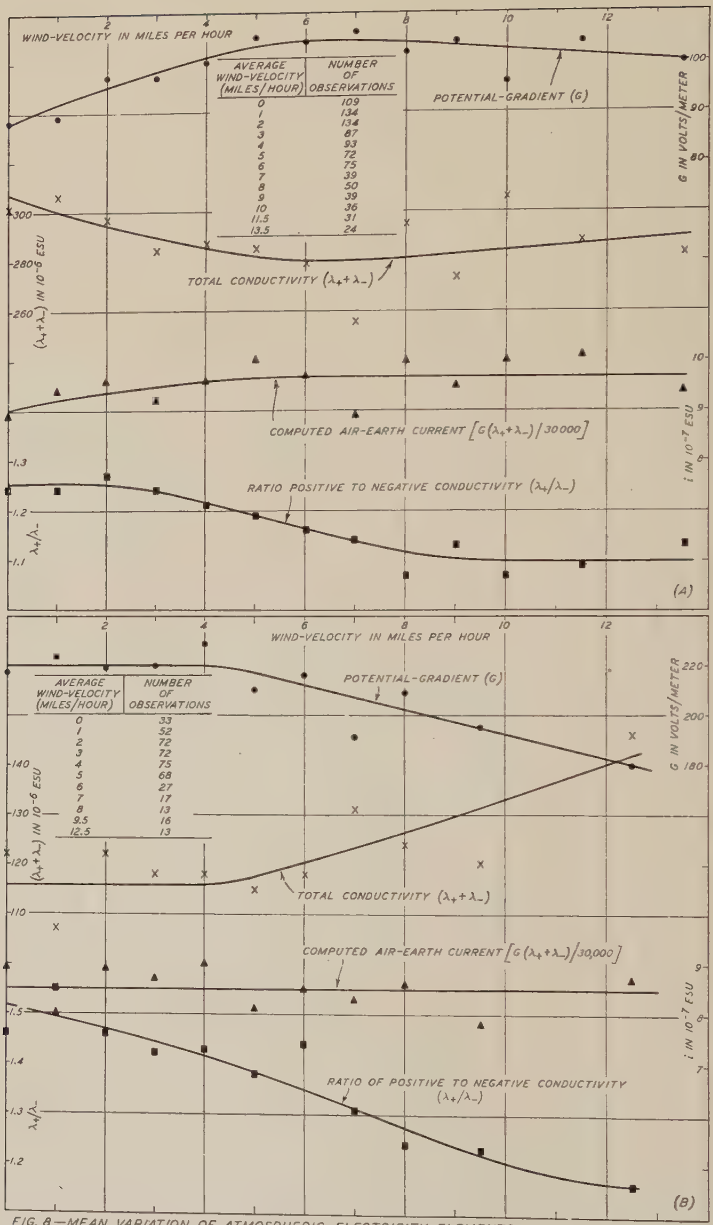

FIG. 8—MEAN VARIATION OF ATMOSPHERIC-ELECTRICITY ELEMENTS WITH WIND-VELOCITY AT WATHEROO, (A) NON-SMOKY AND (B) SMOKY DAYS, INTERVALS 0^h-1^h AND 4^h-5^h, JANUARY TO MARCH, 1924-34

of positive to negative conductivity diminishes from a high value to a normal value for an increase in wind-velocity from 0 to 12.5 miles per hour. The conductivity and the potential-gradient vary in a nearly reverse manner for the non-smoky days. Both elements remain essentially constant for wind-velocities greater than about five miles per hour. For velocities from zero to five miles per hour the conductivity decreases and the potential-gradient, as well as the air-earth current, increases with an increase in wind-velocity. The ratio of positive to negative conductivity, just as for the smoky days, undergoes a decrease with an increase in wind-velocity.

The causes for the variation of the various elements with wind-velocity appear to be consistent, in all cases, with those discussed in connection with Figure 7. On smoky days the accumulation of smoke during times of calm results in a low measured conductivity and a high potential-gradient. The distribution of smoke with altitude appears to be so uniform that moderate mixing produces no appreciable change in its intensity near the ground. For still greater mixing, however, its intensity near the ground diminishes. This appears to be due to something other than a removal of the smoke from the air-column, for the air-earth current remains unchanged. It must be due to the existence of a somewhat greater density of smoke in the lower portion of the column before mixing starts and to the production of a more uniform distribution after mixing. The smoky-day curves of Figure 7 suggest such a distribution in intensity of the smoke with altitude. The strong electric field at such times would be expected to produce a scarcity of negative ions near the ground compared with the number of positive ions, resulting in a large ratio of positive to negative conductivity. During times of calm the number of ions of the two signs would differ most near the ground and would gradually approach equality with altitude. Mixing of the air would tend, therefore, to bring about equality in the number near the ground. This is found to occur for both smoky and non-smoky days. Since the field is more intense for the former class of days, a greater depletion of negative ions would also exist near the ground during times of calm and the ratio of conductivities should consequently be greater. This is completely borne out by the data for smoky and non-smoky days.

The distribution of smoke, as was implied from the results indicated in Figure 7, is very different for the non-smoky days, and the mixing of the air by the wind will have a different effect, therefore, on most of the elements. During calm conditions, smoke or at least condensation-nuclei appear to accumulate in the higher regions of the atmosphere. At the same time it is expected that radioactive matter will accumulate in the air near the ground. The low nuclei-content and the high radioactive content of the lower stratum of air will combine to produce there a high conductivity. As mixing occurs through an increase in wind-velocity, however, the radioactive matter near the ground will be distributed to higher regions having less of this material. At the same time some of the air of the higher regions richer in condensation-nuclei will be brought down and increase the nuclei-content of the lower air. Both combine to decrease the conductivity of the air near the ground and to increase the potential-gradient. Some of the nuclei, through this procedure, would likely settle to the ground and thus be removed from

the vertical air-column. This process would reduce the total resistance of the vertical air-column and result in an increase in the air-earth current. For higher wind-velocities no further change in the atmospheric-electric elements takes place; this suggests that further mixing does not alter the distribution of the nuclei and radioactive matter and that uniform distribution, therefore, has been achieved. These results appear to be entirely consistent with those indicated by Figure 7 and thus assist in a better understanding of the distribution of radioactive material and of condensation-nuclei for various circumstances at Watheroo.

The rate at which the small ions in the lower atmosphere are produced does not appear to be as constant through the day at some land stations, as is frequently supposed, but undergoes a considerable diurnal variation. A certain type of variation appears to be rather faithfully followed on the majority of days. A maximum in the rate of ionization occurs, according to observations with a thin-walled ionization-chamber in the suburbs of Washington, D. C., during the early morning and a minimum during the evening. The daily maximum coincides in time with the daily increase in wind-velocity, while the minimum occurs at the time of the subsidence of the wind towards evening. The cause for this daily variation in the rate of ionization is believed to be an accumulation of radioactive material in the lower atmosphere during times of low wind-velocity and a subsequent dispersal of the radioactive matter through the stirring action during times of higher wind-

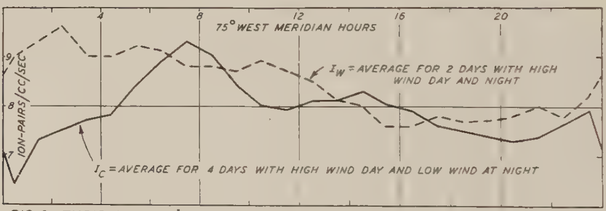

FIG. 9—TYPICAL DIURNAL VARIATION IN IONIZATION FOR PERIOD LOW WIND AT NIGHT AND ABSENCE OF SUCH VARIATION FOR PERIOD HIGH WIND AT NIGHT, WASHINGTON, APRIL, 1936

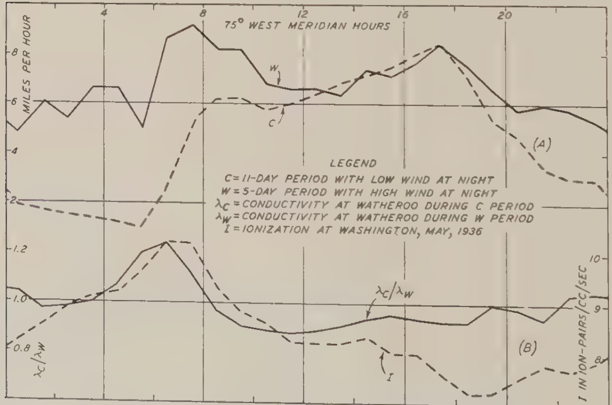

FIG. 10—COMPARISONS OF (A) WIND-VELOCITIES AT WATHEROO, NOVEMBER, 1928, AND (B) IONIZATION INSIDE THIN-WALLED CHAMBER AT WASHINGTON WITH RATIO OF CONDUCTIVITY IN FREE AIR AT WATHEROO

velocity. According to such an explanation, the rate of ionization would fail to pass through the usual maximum if the wind failed to drop to low velocities during the day or night. Occasions when the wind-velocity remains high during the night as well as during daylight in Washington are rare. Search of the records revealed that this did occur for a two-day period, on April 15 and 16, 1936, when recordings of ionization were available. The mean ionization, in ion-pairs per cc per second inside the chamber for the two-day period, is plotted as a diurnal-variation curve in curve I_W of Figure 9. The ionization, as was to be expected on the basis of the above hypothesis, did not pass through the usual daily maximum. It might be explained that, while the ionization was relatively high on this occasion, particularly during the early morning, it was perhaps not directly due to the high wind. This high ionization appears rather to be associated with a cold front that passed the station during the last few hours of April 15. The new air-mass apparently contained large quantities of radioactive matter which caused the ionization during these few hours to quickly assume high values. The ionization did not, however, pass through the diurnal-variation characteristic of this element until the velocity of the wind died down at night whereupon the usual type of diurnal variation was resumed as indicated by curve I_C, which depends on the mean data of four days, two days before and two days after the two-day period, that is, April 14, 15, 18, and 19, 1936. The velocity of the wind on all four days decreased as usual to low values at night and increased to moderately high values during daylight. The curve I_C for only four days agrees closely with that for a much greater number of days as may be seen by comparing it with curve for I in Figure 10, the mean of 17 days during May, 1936. The results indicated by curves I_W and I_C of Figure 9 are in complete agreement with the hypothesis outlined above concerning the cause for the diurnal variation in ionization usually encountered at Washington, and presumably followed at many other land stations as well. It might be pointed out that the factor required to reduce values of ionization inside the chamber to equivalent ionization in the free atmosphere is not well known and consequently no attempt at reduction is made. Attention may be called to the fact that the number of large ions during the two-day period of April 15 and 16, passed through the usual type of diurnal variation, reaching a maximum between 20^h and 21^h, 75° west meridian time. This result suggests that the maximum in the large-ion curve, even though it occurs at a time when the wind is becoming calm, is not due to the diminished velocity of the wind.

Any change in the rate of ionization will tend to bring about a corresponding change in the conductivity of the air. A comparison of the conductivity of the lower air at Watheroo for a period when the wind did not drop at night with that for a period when the wind diminished as usual at night is of considerable interest. The ratio of conductivity (λ_C) during the latter period to that (λ_W) during the former period, unless the diurnal variation in nuclei-content of the air on the two occasions is considerably different, will vary through the day in a manner similar to the rate of ionization. The diurnal-variation curve for this ratio for periods during November, 1928, is shown as one of the curves of Figure 10 together with diurnal-variation curves for wind-velocity during the two periods. The curve for the ratio shows considerable similarity

to the curve for rate of ionization at Washington during a corresponding period of the year. This is interpreted to mean that the diurnal variation in the rate of ionization at Watheroo is similar to that at Washington. If the rate of ionization of the lower air varies through the day at Watheroo in the same manner as at Washington, the conductivity should pass through a maximum during the early morning unless distorted by a variation in the condensation-nuclei content of the air. Examination of the two conductivity-curves at Watheroo, shown in Figure 1, indicates that for both smoky and non-smoky days a maximum is reached during the forenoon. The time of the maximum is somewhat delayed, however, in the case of the smoky-day curve. A comparison of these curves with that for ionization at Washington during May, 1936, as illustrated in Figure 10, is of interest. The ionization-curve shows considerable similarity to the conductivity-curve for non-smoky days but much less to that for smoky days. This suggests that the nuclei-content of the lower air varies to a lesser extent on the non-smoky than on the smoky days and that the variation during the latter period is sufficiently large to distort appreciably the conductivity-curve. The curve connecting the hourly values of the ratio of conductivity on non-smoky days to that on smoky days will closely parallel, therefore, the diurnal-variation curve of condensation-nuclei content of the lower air on smoky days, assuming that the rate of ionization on the two types of days is essentially the same. Diurnal-variation curves of the ratio for the positive and the negative conductivity are shown in Figure 2. It is seen from these curves that the condensation-nuclei content of the air increased to high values at night and decreased to about half these values during daylight. These curves have already been discussed from the point of view indicating that smoke is more intense during night than during the day.

The total resistance of a vertical column of air over Watheroo appears to have a systematic diurnal variation. The maximum resistance occurs during the night and the minimum during the forenoon, as indicated by the curves for the ratio (i_O/i_W) illustrated in Figure 7. The factors responsible for this particular type of variation are not immediately apparent. One might attribute this variation to a change in the condensation-nuclei content of the vertical column. The changes can be accounted for in some cases only with difficulty. On smoky days the required change in nuclei-content of the vertical column through the day and its distribution with height can be readily accepted. The number of nuclei must be more or less uniformly distributed with height and remain so throughout the day. The number in a given unit-volume of air must vary through the day, however, more or less as the total resistance, being greatest during the night and least during daylight. This same type of variation in the nuclei-content of the air must also prevail during the non-smoky days. The distribution appears to be uniform with height except for a few hours during the morning when it increases with altitude (if nuclei alone are recognized as the responsible factor). Such a condition is required not only for the non-smoky days of the summer season, but for practically all days during the autumn, winter, and spring as well. On non-smoky days during the summer, the number of nuclei may well vary more or less throughout the entire column in the manner required. The chief reason some days are classed

as smoky while others are classed as non-smoky may be due to the fact that in the former class the origin of the smoke is not far removed from the Observatory while in the latter case the origin may be more distant. In both cases the fires may be kindled mostly at night and allowed to die out during the daytime. The required vertical distribution of nuclei may be accepted also, for smoke from more distant fires might increase in intensity with altitude but not arrive at the Observatory till about midnight as required. This same argument cannot, however, be advanced in the case of the remaining seasons of the year. Smoke then is not in any way discernible at the Observatory, and the kindling of fires in the bush is prohibited by law. There are no large industrial sources of smoke closer than Perth, some 120 miles distant. It is difficult to believe that any great disturbance could reach the Observatory so systematically from such a great distance. The ocean is 55 miles away, and one might question the possibility of a contribution in the form of salt crystals, etc., serving as nuclei reaching the Observatory at the time of day required. Attention must be called to the fact that the total resistance at Huancayo and Tucson also varies through the day in a manner quite similar to that at Watheroo [6]. The variation at these stations also differs very little with season. It would not seem possible, therefore, to offer any specialized explanation of the diurnal variation in resistance at Watheroo. It seems necessary to assume that the explanation is applicable for stations such as Huancayo and Tucson as well. One might consider the combined effect of condensation-nuclei and radioactive matter on the total resistance of the air-column. The amount of radioactive matter in the air near the ground appears to vary systematically through the day. Unless it varies also through a considerable vertical thickness, its effect would not be sufficient to account for the observed variation in resistance. Too little is definitely known concerning the amount of radioactive matter in a whole vertical column of air at different times of the day to permit profitable speculation on this point. Additional investigations may assist in throwing light on the causes for the apparent diurnal variation in resistance of the vertical column of air at Watheroo and at other stations where atmospheric-electric data are available.

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Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C., March 4, 1943

PRINCIPAL MAGNETIC STORMS

Sitka Magnetic Observatory

October to December, 1942

(*Latitude 57° 03'.0 N., longitude 135° 20'.1 or 9^h $01^m.3$ W. of Gr.*)

October 2-5—Beginning gradually just before 09^h GMT, October 2, a disturbance of moderate severity continued through the night of October 5. *K*-indices of 7 were recorded for the periods 12^h-15^h on October 2 and 03^h-06^h on October 3.

October 12—Between 10^h and 13^h GMT, Ocober 12, there was first an increase then a decrease in *D* giving a range of 110′. At the same time there was recorded a range of 500 gammas in *H*. The traces continued to be slightly disturbed for several days.

October 28-30—From an undisturbed condition at 09^h GMT, October 28, a disturbance began to emerge which at 13^h, suddenly became severe for six hours, moderated until 05^h 25^m, October 29, again became violent, and with diminishing intensity continued through October 30. *K*-indices of 7 were recorded during five, and of 8 during two three-hour periods.

November 23-24—From a small beginning about 06^h GMT, November 23, a disturbance slowly increased in intensity to a maximum between 09^h and 10^h, November 24, when a *K*-index of 9 occurred. Succeeding days were marked by moderate activity.

December 20—A nine-hour period of moderate disturbance occurred between 09^h and 18^h GMT, December 20, when a *K*-index of 7 was recorded.

December 23—Beginning moderately at about 06^h GMT, December 23, a disturbance suddenly became rather severe with a sharp decrease in *H* at 08^h 41^m of about 350 gammas, followed by seven hours of fairly rapid oscillations of small magnitude combined with irregular variations of larger degree.

Harold W. Pinckney, *Observer-in-Charge*

Cheltenham Magnetic Observatory

October to December, 1942

(*Latitude 38° 44'.0 N., longitude 76° 50'.5 or 5^h $07^m.4$ W. of Gr.*)

October 2-5—A moderately severe storm began rather indefinitely at about 10^h 50^m GMT, October 2, and lasted until about 15^h, October 5. The first ten hours of the storm were marked by very short-period activity, particularly in *H*, superimposed on slower variations. The severest part of the storm came in the first six hours of October 3, during which two *K*-indices of 6 were recorded. Thereafter the activity was not violent.

October 28-30—Another storm of somewhat greater severity began at about 12^h 20^m GMT, October 28, and lasted about forty-eight hours,

although minor activity continued for some time longer. Irregular variations of large amplitudes and long periods were predominant. Two K-indices of 7 were recorded in the third and fourth three-hour periods of October 29.

November 23-24—A moderate storm began indefinitely at about 21^h 45^m GMT, November 23. The fluctuations were of an irregular character. The storm proper appeared to have ended at about 14^h, November 24, although some activity occurred at intervals for several days afterward. Two K-indices of 6 were recorded during the storm. During the first hour of the disturbance Z increased about 60 gammas, then gradually decreased to about 110 gammas below its normal value at 09^h 50^m, November 24. About two hours thereafter its value was normal again.

JOHN HERSHBERGER, *Observer-in-Charge*

TUCSON MAGNETIC OBSERVATORY

OCTOBER TO DECEMBER, 1942

(*Latitude 32° 14′.8 N., longitude 110° 50′.1 or 7^h $23^m.3$ W. of Gr.*)

October 2-5—A moderate magnetic storm began at 02^h 47^m GMT, October 2, with a small but definite increase in H (about 17 gammas). The activity was slight until about 12^h, October 2, at which time the disturbance became quite pronounced. The principal activity was over by 12^h, October 3, but minor variations in D and H continued until about 14^h, October 5. Ranges: D, 16′; H, 141 gammas; Z, 46 gammas.

October 11-16—A very mild storm began about 18^h GMT, October 11. It was characterized by low amplitude swings of D and H, and by a considerable amount of short-period activity. The storm ended about 03^h, October 16. Ranges: D, 19′; H, 125 gammas; Z, 32 gammas.

October 28-31—A moderately severe storm began without sudden commencement at about $09^h.5$ GMT, October 28. The intensity of the storm increased within a few hours and reached probably its greatest activity by about 24^h, October 28. The Greenwich day October 29 exhibited some fairly large swings in both D and H, after which the activity gradually decreased until the end of the storm, about 15^h, October 31. Ranges: D, 18′.5; H, 182 gammas; Z, 38 gammas.

November 23-27—A moderate storm began about 15^h GMT, November 23. The first eight hours were marked by a decreasing value of H, after which D and H exhibited some fairly large variations. The long-period activity died down somewhat about twenty-four hours after the beginning of the storm, but there was noticeable short-period activity during the following ten hours. Minor disturbance, with occasional swings in D and H lasting from one to four hours, continued until about Greenwich noon, November 27. Ranges: D, 20′; H, 143 gammas; Z, 37 gammas.

December 9-10—A very mild storm, beginning about 14^h GMT, December 9, was characterized chiefly by about ten hours of low values of H, without a great deal of activity. There was mild disturbance of D. The storm ended about 09^h, December 10. Ranges: D, 12′.5; H, 88 gammas; Z, 34 gammas.

December 20-22—A moderate storm began, without sharp commencement, about 18^h GMT, December 20. The activity of *D* and *H* gradually increased to a maximum about the middle of the Greenwich day December 21, then gradually decreased until the end of the storm, about 14^h, December 22. Ranges: *D*, 19′.5; *H*, 98 gammas; *Z*, 25 gammas.

December 23-25—A moderate storm began, without sharp commencement, about 06^h GMT, December 23, and reached its maximum activity in about six hours. At about 21^h, December 23, the principal activity died out, leaving *H* rather low. Beginning again about 05^h, December 24, there occurred some slow swings in *D* and *H*, of moderate amplitude. The storm ended about 04^h, December 25. Ranges: *D*, 16′; *H*, 101 gammas; *Z*, 26 gammas.

J. H. Nelson, *Observer-in-Charge*

Huancayo Magnetic Observatory

October to December, 1942

(*Latitude 12°02′.7 S., longitude 76° 20′.4 or 5^h 01^m.4 W. of Gr.*)

October 2—Beginning at 02^h 47^m GMT, October 2, with a sharp short rise in *H*, there was a moderate magnetic disturbance which was marked by a number of narrow peaks and bays in the *H*-trace with a maximum range of about 200 gammas during the daylight hours of October 2 and followed by subnormal *H*-values for several days. *D* and *Z* were only mildly affected during the hours of maximum disturbance.

October 28-31—About forty-two hours after an observed active prominence on the limb of the Sun, a strong magnetic disturbance gradually developed beginning at about 12^h GMT, October 28. There were several small peaks and bays in *H* until after 16^h, followed then by a marked decrease and two large bays, the range during these hours of daylight being about 385 gammas. *H* was definitely disturbed both during the daylight and darkness hours for about three days altogether and recorded unusually low mean values during this time and continuing several days longer. Both *D* and *Z* were moderately disturbed on October 28, but showed only minor disturbance thereafter.

November 22-28—Apparently beginning with a number of small pulsations in *H* on November 22, a minor magnetic storm developed gradually on November 23 which lasted more or less continuously through November 26 and then flared up again on November 28. The greatest activity was registered on November 23 during the daylight hours when in addition to moderate fluctuations in *H* there were two deep bays, the second of which was the beginning of unusually low values in *H* which continued practically to the end of the month. The activity during the remaining part of the storm was confined to moderately rapid and smaller fluctuations in *H* both during the daylight and night-time hours and to slight activity in *D* and *Z* during the daylight hours.

December 9—A short magnetic disturbance began at 15^h 06^m GMT, December 9, with a sharp decrease in *H* followed by several moderately deep bays and high peaks. It ended at about 20^h and was followed by only very slight decrease in *H*-values. *D* and *Z* showed only slight disturbances.

December 20-21—The *H*-trace showed a very mild disturbance from about 19^h GMT, December 20, but a sharp decrease took place at $13^h\ 35^m$, December 21, followed by nearly five hours of marked disturbance with several long peaks and bays. *D* and *Z* showed practically no effect, but the *H*-trace was low for a few days and mildly disturbed during the daylight hours.

PAUL G. LEDIG, *Observer-in-Charge*

MAGNETIC OBSERVATORY, HERMANUS

OCTOBER TO DECEMBER, 1942

(*Latitude 34° 25′.2 S., longitude 19° 13′.5 or $1^h\ 16^m.9$ E. of Gr.*)

October 2-5—A sudden-commencement storm began at $02^h\ 46^m$ GMT, October 2. *H* increased 21 gammas in five minutes. At first the disturbances were small and were characterized by pulsations and oscillations on all traces from 08^h to 19^h, October 2. The intensity of the storm gradually increased until bays of *K*-index 6 were formed on all traces at 20^h to 21^h, October 2. On October 3 at 01^h and 04^h, bays of *K*-index 4 were formed on all traces. Disturbances continued until 01^h, October 5.

October 6-7—Abrupt changes took place at $16^h\ 30^m$ GMT, October 6, but it was only in the period from 21^h, October 6, to 03^h, October 7, that the disturbances had a range of *K*-index 3.

October 11-20—Gradual-commencement disturbances continued from 09^h GMT, October 11, to 19^h, October 20. The largest *K*-indices were 5 in the periods 18^h to 21^h, October 11, and 09^h to 12^h, October 12. *K*-indices of 4 occurred in the four three-hour periods in the afternoon of October 12. Pulsations were evident on all traces particularly during the periods from 08^h to 18^h, October 12, 09^h to 22^h, October 13, 07^h to 22^h, October 14, 08^h to 18^h, October 17, and 08^h to 18^h, October 20.

October 28-31—A gradual-commencement storm began at about 11^h GMT, October 28, and continued until 24^h, October 31. There were *K*-indices of 6 in the two three-hour periods, 15^h to 21^h, October 28, and of 5 in the periods from 12^h to 15^h and 18^h to 24^h, October 28, 09^h to 18^h and 21^h to 24^h, October 29, and of 4 in the periods from 03^h to 09^h and 18^h to 21^h, October 29.

November 4-5—At $11^h\ 33^m$ GMT, November 4, sharp pulsations were recorded on all traces with a sudden change of *H* of 4.6 gammas. During the period from $11^h\ 33^m$, November 4, to $05^h\ 19^m$, November 5, there were several groups of small regular oscillations or pulsations on all traces, particularly sharp and distinct on the *H*-trace. The ranges of the oscillations were little more than a broadening of the trace. At $05^h\ 19^m$, November 5, there were changes indicating a second phase when there was a small increase in *H*, a small increase in westerly *D*, and a small numerical increase in *Z*. At $18^h\ 04^m$, November 5, a sudden-commencement disturbance started when *H* increased 13.6 gammas in six minutes, *D* showed a small easterly shift, and *Z* a small numerical increase. The periods of the two phases were 12.7 hours and 17.8 hours, a total interval of 30.5 hours between the first impulse and the sudden commencement.

December 2-7—There were small oscillations and pulsations on all traces from $23^h 45^m$ GMT, December 2, to $00^h 12^m$, December 3, from $21^h 05^m$ to $23^h 20^m$, December 4, at 12^h, December 5, from $10^h 53^m$ to $11^h 01^m$, December 6, from $09^h 17^m$ to $09^h 43^m$ and $22^h 25^m$ to $23^h 05^m$, December 7. From $14^h 29^m$ to $14^h 39^m$, December 6, pulsations were recorded similar to those of Figure 7, page 228 of the September 1942 issue of this JOURNAL.

December 8-9—An abrupt change at $12^h 04^m$ GMT, December 8, developed into disturbances with K-indices of 4 in the period from 12^h to 24^h, December 9.

December 11—Bays with K-indices of 4 accompanied by micro-oscillations were recorded in the period from 21^h to 24^h GMT, December 11.

December 19-26—There was an abrupt shift of the H-trace at $08^h 20^m$ GMT, December 19. Micropulsations were evident at 16^h and became very sharp and distinct during the period from 21^h to 24^h, December 19. The disturbances gradually developed and reached a maximum in the period from 12^h to 15^h, December 21, when K-index of 5 was recorded. The disturbances continued until 24^h, December 26.

Hermanus, South Africa A. OGG, *Magnetic-Survey Adviser*

NOTES

1. *Magnetic field-work in Argentina*—Referring to the information given in previous notes in this JOURNAL (**46**, p. 374, 1941, and **47**, pp. 154, 341, 1942) we have learned that the field-work planned for 1937-42 for the purpose of obtaining information regarding the secular variation has been brought to a successful conclusion. During the period September 8 to December 3, 1942, the last seven stations were reoccupied. They were as follows: Corrientes, Corrientes; Puerto Aguirro, Missiones; Concepción del Uruguay, Entre Ríos; Puerto Belgrano, Buenos Aires; Trelew, Chubut; Puerto Deseado, Santa Cruz; Río Gallegos, Santa Cruz.

2. *Repeat-stations in South America*—Joel B. Campbell and Fred Keller, Jr., magnetic observers of the United States Coast and Geodetic Survey, are operating in South America in connection with the American Republics co-operative program for occupying repeat-stations. They have completed observations in Venezuela, Colombia, Ecuador, Peru, Bolivia, and Chile. Diurnal-variation observations were made at two stations in Ecuador and one in Chile. Comparison observations were made during January 1 to 5, 1943, between their instruments and those of the Huancayo (Peru) Magnetic Observatory of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

3. *Total eclipse of the Sun, Alaska, February 4, 1943*—The opportunity for observing the solar eclipse of February 4, 1943, was taken at the College Observatory (Alaska) of the University of Alaska and the Carnegie Institution of Washington. Although the eclipse did not quite reach totality at that station, special ionospheric observations were successfully carried out. At the same time visual observations and time-corrections were made.

4. *Magnetic work of the United States Coast and Geodetic Survey*—The Coast and Geodetic Survey has in the press the magnetic observatory results for the following observatories: Tucson 1931-32; Sitka 1933-34; Tucson 1933-34; and Honolulu 1933-34. The new isogonic chart for the Caribbean Sea and adjacent areas is also in the press.

Computations for magnetic work are still in progress in the computing office of the Coast and Geodetic Survey in New York. The office is in charge of Lieut. Commander A. P. Ratti, with A. Gottfried supervising the magnetic computations.

5. *Magnetic anomalies in Alaska*—The following notes regarding magnetic anomalies in Alaska are taken from the *Hydrographic Bulletin* (No. 2778, December 2, 1942) of the United States Navy:

Local attraction or abnormal magnetic attraction caused by veins of mineral magnetite, paramagnetic rocks, or polarized ferromagnetic substances in land masses, or under the ocean beds of Alaskan waters, has caused normal variations of the compass to be altered in the following localities:

Dixon Entrance to Skagway: Inside Passage—Magnetic observations taken on the mainland, or off-lying islets, indicate that local attraction

is prevalent in this region. Normal variation is increased or decreased on shore from 5° to 30°, while observations at various places in the main channel indicate alterations from 5° to 15° from normal values.

Prince William Sound: Cordova and Orca—Variations observed on shore, differ from normal by a decreasing value of 1°.

Cook Inlet and Kodiak Island—A maximum disturbance of plus or minus 3° has been observed on the land, although values in Kodiak and St. Paul Harbors are about normal.

Alaska Peninsula: Southern shore—Magnetic disturbance on land causes variations from mean values as high as 14° and as much as 2° on courses close inshore.

Aleutian Islands: Unalaska to Rat Islands—Local attraction has been observed at shore stations on the various islands and magnetic variation changes from normal values by increasing and decreasing amounts from 2° to 8°. At Dutch Harbor variation is increased 1° from normal.

Pribilof Islands: St. Paul and St. George Islands—Land observations indicate local attraction that varies 4° to 11° from normal.

6. *Temperature of the atmosphere*—At a colloquium in a series arranged by the Manchester University Branch of the Association of Scientific Workers, Dr. T. G. Cowling delivered an address, December 2, 1942, on "The temperature of the atmosphere." With regard to the variation of temperature with altitude, Dr. Cowling suggested a possible explanation for the fact that the temperature ceases to decrease at a height known as the tropopause. According to this theory, solar energy is absorbed by ozone in the stratosphere, and in the absence of any gas with strong emission-bands in the infrared, the temperature is increased. Water-vapor has broad intense bands in the infrared, and when it is present tends to keep the temperature low. In considering variations of the temperature in the stratosphere with season and latitude, account must be taken of any variations of the concentrations of gases such as ozone and water-vapor, as well as of the intensities of the radiations coming from the Sun to the Earth. During the discussion that followed, Dr. L. Jánossy pointed out that the tropopause falls rapidly at the same latitude that shows a marked increase in cosmic-ray intensity. Cosmic rays might conceivably produce some ozone, and so account for the higher temperature over the poles. (*Nature*, December 12, 1942.)

7. *Awards of the Foundation for the Study of Cycles for 1943*—The Foundation for the Study of Cycles—a non-profit organization created to foster, promote, and conduct scientific research in respect to rhythmic and periodic fluctuations in any branch of science—announces the offering of a medal to the person who, during 1943, publishes the book or paper in that field that in the opinion of the judges is the most outstanding.

Some of the reasons for assigning high importance to research in cyclic phenomena are outlined by the Foundation. First, in dealing with rhythm and periodicity, the scientist is at the heart of predictability. The power of predicting accurately is the acid test of the degree of precision reached in any science. For example, accurate long-range weather predictions, which would be of inestimable value in agriculture

and aviation, depend on a knowledge of the nature and causes of the more or less rhythmic variations observed now and in the past. Second, the techniques for dealing with rhythms and periodicities are much the same in one branch of science as in another, but unless the subject is considered a field by itself, advance in methods in one discipline is often unknown in another until after a lapse of many years. Thus the subject of rhythmic and periodic fluctuations is important because identical rhythms in unrelated fields of science suggest possible interrelationships that might otherwise escape notice. For instance, long before the cause of tides was understood, the fact that the period of the tides is exactly half the period of the Moon suggested that the Moon must have something to do with the ebb and flow of the waters.

In addition to awarding a medal, the Foundation will make awards to outstanding work in each branch of science. In these awards, the judges will be assisted by the recommendation of an advisor appointed by a scientific society in the branch involved. The person receiving the medal and those receiving the awards will be elected Fellows of the Foundation. Communications should be addressed to Professor Ellsworth Huntington, Chairman of the Committee on Awards, Hendrie Hall, Yale University, New Haven, Conn.

8. *Earth-current registration at Tucson, Arizona*—Earth-current registration, which was inaugurated in March 1931 under a cooperative arrangement between the American Telephone and Telegraph Company, Mountain States Telephone and Telegraph Co., the United States Coast and Geodetic Survey, and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, was continued without serious interruption until March 1, 1943. It was found necessary for the Telegraph Companies to discontinue the arrangements because of commercial requirements. Thus records were obtained over approximately a sunspot-period. The data obtained are adequate for giving a fairly satisfactory description of the diurnal variation and its annual changes but some aspects of the latter challenge further investigation. Plans are being made to resume the registration at Tucson, using shorter lines especially for the purpose of studying disturbances and storm-effects.

9. *Chree Medal and Prize for 1943*—The Council of the Physical Society of London has awarded the Charles Chree Medal and Prize for 1943 to Professor (now Colonel) *B. F. J. Schonland*. Colonel Schonland, formerly professor of physics at Cape Town and later director of the Bernard Price Institute of Geophysics at Johannesburg is now in Great Britain engaged in scientific work in connection with the War. The following note is as given in *Nature* [February 20, 1943]: "Professor Schonland's work on atmospheric electricity has been primarily concerned with thunderstorm phenomena; first his investigations of the 'polarity' of thunderclouds in South Africa, and his measurement of the discharge from a small tree, which clearly established the importance of point discharges in maintaining the Earth's negative charge; secondly, his systematic long-period observations on the interrelation of thunderstorms and penetrating radiation in the Southern Hemisphere; and thirdly, his use of a rotating-lens camera of the Boys type in a spectacularly successful series of systematic experiments which elucidated the rather complicated succession of discharges forming what is known as a 'stroke' of lightning."

10. *Corrigenda*—The following corrections are to be made in the Figures of the article by Dr. A. Ogg on page 228 of the September 1942 issue of the JOURNAL: Read "Fig. 4—November 24" for "Fig. 4—March 24"; read "Fig. 6—November 10" for "Fig. 6—March 16"; read "Fig. 9—December 28" for "Fig. 9—December 8."

11. *Personalia*—The Rumford Medal has been awarded by the President and Council of the Royal Society to Dr. *G. M. B. Dobson*, F. R. S., for his outstanding work on the physics of the upper air and its applications to meteorology.

The September 1942 issue of *Earthquake Notes* carries an announcement of the death of Dr. *Edmond Rothé*, who was for many years the Director of the Institut de Physique du Globe at Strasbourg. He was a familiar figure at the meetings of the International Union of Geodesy and Geophysics as Secretary of its Association of Seismology.

We note in *Science* an announcement of the death at the age of seventy-seven years of Professor *Carl Dorno*, founder and former director of the Davos Physical Meteorological Observatory, at Davos-Platz, Switzerland.

We regret to record the death of Dr. *C. Coleridge Farr*, Emeritus Professor of Physics at Canterbury College, Christchurch, New Zealand, on January 27, 1943, in his seventy-seventh year. In 1916 Dr. Farr published "A magnetic survey of the Dominion of New Zealand and some of the outlying islands for the epoch 30th June, 1903." Dr. Farr was chiefly responsible for the initiation and success for this important survey which was carried out during the period 1899 to 1909.

LIST OF RECENT PUBLICATIONS

BY H. D. HARRADON

A—Terrestrial and Cosmical Magnetism

AUSTRALIA. Magnetic declination base-map for epoch 1942.5, Australian aeronautical series, sheet 1. Mercator projection. Compiled and drawn from magnetic data reduced by J. M. Rayner, Chief Geophysicist, Mineral Resources Survey, Department of Supply and Development. 88 x 95 cm. Canberra, Property and Survey Branch, Dept. of Interior (Oct. 17, 1942). [Absolute values are derived from the following authorities—Carnegie Institution of Washington; Mr. Dodwell, Government Astronomer, unpublished results; Aerial, Geological and Geophysical Survey of North Australia, unpublished results (1936-42). Inset maps show secular variation of magnetic declination for the epoch 1935-1940, and magnetic anomaly in the vicinity of Yorke's Peninsula.]

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BENEDIKT, E. T. A method of determination of the direction of the magnetic field of the Earth in geological epochs. Amer. J. Sci., **2**, No. 241, 124-129 (1943). [Sediments of ferromagnetic particles, deposited in a magnetic field, are magnetically anisotropic. This has been established for artificially prepared sediments in a previous work of the author. In the present work it is shown that a class of fine-grained sedimentary rocks (blue clay of the Boston Basin) exhibits the same type of anisotropy. This property can be expected to be general for rocks of the above type, and it can be used for the determination of the declination of the magnetic field of the Earth at the epoch of the sedimentation of the specimen.]

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B—Terrestrial and Cosmical Electricity

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